THE

METAPHYSIC OF EXPERIENCE

VOL. II.

THE

METAPHYSIC OF EXPERIENCE

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THE

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BOOK II.

POSITIVE SCIENCE.

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BOOK II.

POSITIVE SCIENCE.

CHAPTER I.

THE BIRTH-PLACE OF SCIENCE.

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§ 1. The analysis of Book I. has shown us the nature of the experiences, out of which our conception of a real world of persons and things, actions and events, is framed, and by reference to which, as evidence at any time available, its truth is tested. It has disclosed to us a world, or objective panorama, of real objects thought of, consisting of two classes of real existents, briefly named Matter and Existent Consciousness, in contrast to the objective thought, or (psychologically) subjective panorama, by which we picture or think of it. And within the former, or world of real existents, it has farther revealed the distinction which separates existents which are both real conditions and conditionates from existents which are real conditionates only. The common-sense conception of the universe in which we live, speaking of it broadly or in its main outlines, is thereby at once explained and justified. And the task which lies next before us is to follow up the conception of the world of real conditions, the realities of the real panorama, which we have obtained by this analysis, and see how it has been and is now being treated by those who have taken it as their *datum*,

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and explored it with the utmost attainable accuracy of observation, experiment, and thought. I mean, of course, the methods, conceptions, and results of Positive Science.

The purpose of Science I take to be this, to acquire a demonstrable and exact knowledge of the Course of Nature, and of the uniformities included in it, by means partly of conceptual analysis, similar to that described and exemplified in the foregoing Book, and partly by methods subsidiary to it. In this it is implied, that a knowledge of the merely historical sequence of events in the Course of Nature, even supposing it could be fully attained, is neither the whole nor even the principal purpose of science. It is doubtless included among its purposes, as an end which might conceivably be attained by construction of the results acquired in the various analytic departments of science, supposing these sufficiently exhaustive of the facts studied by each. Not that either an absolute beginning or an absolute end of the world-history would even then be attainable. Some real condition, to us inaccessible, must always be supposed to have existed in reality, prior to whatever state of Matter we might have reasons for assuming as the earliest positively conceivable. And similarly with regard to the future. I mean, that, whatever state of Matter we might have reasons for regarding as that in which the world-history is to come to its close, some real existent or existents, inaccessible to us, but conditioned either upon the existents which furnished the real conditions of the material world, or upon these together with the world conditioned by them,

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must be conceived as following it. So that, if we conceive the purpose of science attained by an exhaustive knowledge of the world-history from beginning to end, we thereby conceive the world-history itself as a portion of a larger whole which escapes our comprehension.

But this, as I have said, is only one among the purposes of science in its entirety. The main work of science is done in departments, and these are divided and subdivided with indefinite minuteness. And here it is not history but Law, which is the purpose aimed at. General facts, uniformities, or laws, are what all science seeks; these three terms alike meaning, that similar real conditions are accompanied or followed by similar conditionates, no matter where, when, or how often, those conditions may occur in the whole world-history or Course of Nature. That general facts, uniformities, or laws, in this meaning of the terms, are to be found universally, whatever particular facts may be brought under examination, is what is known as the Law of Uniformity in Nature. In this comprehensive sense, in which it embraces all particular uniformities under it as cases, it is an Ideal Law, or Expectation, which still awaits its full verification by the progressive results of science. At the same time it is no mere hypothesis, which may possibly turn out false when tested by experience, inasmuch as it is the only expectation, concerning facts, which we can frame in thought; the negation of it being incompatible with the thought of any really existent object whatever; or, what is the same thing, its contrary, perfect Chaos, being absolutely

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inconceivable. From which it is evident, that the Law of Uniformity, expressed as a Law of Real Conditioning, has its foundations laid in the analysis of real objects, first as objects of perception in time and space, and secondly as objects of comparison, classification, and reasoning, whereby they are conceptualised, and brought under the meaning of general terms, all such terms being the expression of conceptions which originate in processes of purposive attention to perceptual data. The simplest case of similarity between percepts is thus a case of the universal Uniformity of Nature, of which the Law of Uniformity as a Law of Real Conditioning is but the sequel and development. Whenever, therefore, we are unable to verify it in any particular instance, or in other words to exhibit that instance as a case of it, what we must perforce say is, not that the law is here inapplicable to the facts, but that our present acquaintance with the facts is imperfect.

The meaning of the ideal or expectant character attributed above to the Law of Uniformity may perhaps be brought out more clearly, by comparing it with an ideality of another kind, which is also involved in that Law. Similarity, upon which it is founded, has an ideal limit in Sameness. The similarity between phenomena, of which it is the expression, and on which as an observed fact it is founded, can never be actually known to be more than similarity, that is, to be perfect sameness or identity of content, at different times or places, however close it may come to it. Perfect sameness of content, occurring at different times or different places, is the ideal limit of degrees of

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increasing similarity of content occurring at different times or places. But this ideal limit is not what is expressed by the Law of Uniformity. Just as change is an universal phenomenon in consciousness, so motion, or process taking place in matter, is an universal phenomenon in material substances. It is therefore readily conceivable, that no single portion of matter ever continues strictly the same for any empirically perceivable time-duration, and therefore that no event or action between portions of matter ever recurs, or is strictly the same in point of content, at two or more different times. If it was so, then the ideal limit of the law of uniformity would be strictly attained in its case; though we should have no means of testing whether it was so or not.

Now in the actual Course of Nature, that is, in the course of the history or evolution of matter, inorganic as well as organic, Variation appears to be an universal fact or phenomenon. Its existence appears to be one of the most general facts, that is, laws, in Nature. In other words, Variation itself is a case under the general law of uniformity, considered as a law of real conditioning, and forbids us to regard it as a law which can be fulfilled only by perfect sameness of content in numerically different objects or events. The ideality, therefore, which belongs to the Law of Uniformity, strictly as a Law, consists, not in the ideal limit of sameness implied in similarity, but in the absence of any general and positively knowable standard of fulfilment;—that is to say, a standard indicating with certainty, in the case of any two objects or events, one already experienced

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the other not, the kind and the degree of similarity between them, including the similarity of their relations to their surroundings, which would enable us to argue, from the known consequences or conditions of the one, to the as yet unknown consequences or conditions of the other. And this ideality, which is essential to the Law of Uniformity, is likewise essential to the Law of Variation, and not only so, but also to all conceptions of facts as general facts, that is, to all Laws of Nature whatever, embracing or covering particulars which, as single facts, are numerically different from one another.

It is moreover evident, from the above account of the Order of Real Conditioning, and the Law of Uniformity to which (figuratively speaking) it is subject, that the Laws of Nature included under the latter fall into two distinct classes. To the first class belong laws of the nature (in the sense of *whatness*) of those facts or objects, which are both real in the full sense of being real conditions, and are taken as the data or ultimate bases of any science, having been ascertained by analysis of the phenomena which it treats. To the second class belong laws of the genesis, or Real Conditioning, of the phenomena treated by any science, laws which are founded on the nature and laws of its data, and ascertained by bringing its phenomena under them, as cases in which their nature and laws are operative.

Every positive science is thus founded in analysis, just as metaphysic was shown to be in the foregoing Book, the difference lying only in the object-matter; consciousness in its entirety

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being the object-matter of metaphysic, real conditions and their laws that of positive science. It is also clear, and will become more obvious as we proceed, that, since all objects positively knowable as real conditions are objects which occupy time and space, the ultimate data of all positive science must be mathematically analysable, and consequently the foundations of all, in proportion as they approach the ideal end of being exact sciences, must be laid in mathematical analysis.

This whole method of enquiry, it was shown in Book I., is set on foot by the practical necessity for discovering the real conditions of any object or objects which interest us, that is, which we desire either to secure or avoid, increase or diminish. The method of conceptual analysis is first created by, and then subserves, this practical purpose. And subserves it only by the discovery of real conditions.

But this motive and method, and the conception of real condition involved in them, are common to all men; pre-scientific man goes to work in the self-same way. That is probably why he has called himself *animal rationale* and *homo sapiens*. He may have better titles to the designations, but this is the most obvious, that he generalises his perceptions and thereby consciously applies means to ends, with recognition of them in those characters.

Seeing, then, that the method with its essentials is common to scientific and pre-scientific man, in what consists its *differentia* as a scientific method? There can be but one answer. It lies in the degree of exactitude with which the method is

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used. When the conception of objects as real conditions and conditionates is consciously adopted as the guide to inferences about things existing or not existing, happening or not happening; and when in addition to this we analyse those real objects, with a view to ascertain their exact quantitative relations, that is in other words, to apply exact measurement as a means of discovering the general facts or laws which they exemplify;—then we use the method scientifically, and it becomes a scientific method. The conscious application of measurement to existents, with the view of discovering the laws of their real conditioning, is the origin of positive science; and science itself is neither more nor less than the systematic pursuit of this kind of knowledge. Science begins by consciously seeking real conditions; it ends by discovering the order of real conditioning in all its parts and branches.

§ 2. Matter common ground to Science and Philosophy.

§ 2. Now it has been shown above, that real conditions certainly include material things in action and re-action upon one another, whether or not they also include consciousness as a real existent. The conceptual analysis of the course of nature, therefore, falls into two great divisions, first, the conceptual analysis of Matter, in all its various modes of existence, or real conditioning of its parts *inter se*, and secondly the enquiry into the real conditioning of Consciousness as an existent, or as the consciousness of individual Subjects. The first head includes all physical, including biological and physiological, science, the second is psychology. It is plainly necessary to begin with the former.

§ 2. Matter common ground to Science and Philosophy.

Now Matter, as we have seen, has two forms under which it is known to us; one as analysable into the perceptions which constitute our objective thought of it, and the other as analysable into physical molecules, or other kinds of physical content, and their relations *inter se*, these relations being either constant or variable. In one word, then, Matter is common ground, being the common object, of philosophy and science. Philosophy lays hold of it, as it were, by one handle, and science by another; I mean, by the different kind of analysis which each gives of it. But it is one and the same Matter which is the object of both. Coincidence in space and time, verifiable in presentative perception, is the mark of numerical identity. And just as one and the same piece of matter is the object of visual and tactual sensations, different in kind as these sensations are, so one and the same piece of matter is the object of philosophical and scientific analysis, different as are these two modes of analysing it. Were it not for this numerical identity in Matter, their common object, science and philosophy would have no common ground, nor any means of harmonising their different results. The 'Matter' intended and analysed by each would be different in everything but name, and the heterogeneity of the two pursuits would be complete. Nor would psychology be competent to connect them. For psychology, which now combines the study of physical real conditions with that of consciousness in its existential character, would in the case supposed itself lose its status as a positive science; and, since in any case it must treat of conscious-

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§ 2. Matter common ground to Science and Philosophy.

ness as an existent, would become once more simply a department of philosophy, and that department one in which it is difficult to see how any tenable, or even positively conceivable, hypothesis can be framed.

Be it noted, that it would be incorrect to take this account of the relation between philosophy and science as if it meant, that philosophy deals with matter as it appears to us, and science as it really is. If philosophy deals with matter as it appears to us, then science must deal with it as it appears to us to be in reality; the term *in reality* meaning—in the relation (1) of conditionate to its own unknown real condition, and (2) of having its parts reciprocally conditioned *inter se*. The knowledge which science has of matter is not more but less immediate than the knowledge which philosophy has of it. Matter *in itself*, as it is sometimes called, is no more grasped by science than by philosophy. And for the same reason, namely, that matter *in itself* is a fiction of the imagination, an illusion which has no reality, except as an illusion. Science like philosophy is knowledge, that is, belongs to the (philosophically) subjective aspect of existence, and must conform to the subjective nature of knowledge, which is to be knowledge of objects, not of "things in themselves."

§ 3. The perceptual data of Science.

§ 3. It is obvious in the next place, that science, being the conscious quest of real conditions, has some pre-supposed object in knowledge, concerning which it institutes its conceptual analysis. There is in fact, as we have seen above, a knowledge of the external material world which is pre-scientific, and the pre-supposition of science. It is histori-

cally prior, because the common-sense form of knowledge plainly precedes the scientific in order of history, and furnishes the perceptual data which science gives back in the form of exact measurements and general relationships. The world of material perceived objects is therefore the *datum* and *analysandum* of science, the object-matter upon which science goes to work, and the laws of which it is its purpose to discover.

§ 3. The perceptual data of Science.

Now the perceptual knowledge, which constitutes this datum, analysandum, and object-matter of science, is by no means meagre. It is a knowledge of solid material things occupying space, many in number, and at rest or in motion, relatively to one another, in space. I call it perceptual because it appears in perceptual shape when science begins to analyse it, notwithstanding that conception has gone to its making, in the manner set forth in the preceding Chapter. Solid bodies in rest or motion are complex percepts, though our perceptions of them have been thrown into this particular shape by means of conception operating upon simple perceptions as they actually occur in experience. Moreover force is involved in matter, being that feature of it by which it makes itself unmistakably and often irresistibly felt. And both in rest and in motion, time is involved as well as space.

Time, space, matter, number, force, and motion, are therefore involved as percepts, or elements of percepts, in the knowledge which is the object-matter of science, prior to any conceptual analysis which science institutes. I do not say that the recognition of these six things as separate objects,

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§ 3. The perceptual data of Science.

named each by a name of its own, is not due to a conceptual process, moving by way of comparison and classification. But I think it is undeniable, that a knowledge of them as features belonging to common-sense objects precedes science, and that the distinct recognition of them is the first step taken by any scientific process of measurement, comparison, or classification. They are, in short, the most obvious as well as the most general features in the objects of ordinary life, considered as well in respect of their real conditioning as in respect of their several natures, and as such must have offered themselves, as it were, spontaneously to the first systematic attempts of conceptual analysis, directed to the discovery of real conditions. And the motive which guides science in setting this conceptual analysis on foot is but a continuation of that by which pre-scientific thought is animated, that is to say, is some interest or other in the object-matter, which leads men to enquire into the real conditions of those things, in which they are interested, happening or not happening.

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§ 4. It is in this way that science takes the first preliminary steps towards the complete discovery of the laws of real conditioning. It begins by sifting and classifying the phenomena before it, and thus lays the foundation for several distinct branches of scientific enquiry, that is, for what afterwards become the several main departments of positive science. It classifies together and separates from other things those elements in the external world which it considers to be ultimate, that is to say, incapable of further explanation, in their own nature, and at the same time considers

to be the conditions of existence of other things. It then gives unity in thought to these abstractions, but without robbing them of that reality which they possess as belonging to the really existent world from which they are abstracted.

The real conditions, or elements of real conditions taken as objectively real, which on such a method must finally come to be considered as ultimate and fundamental (for I do not propose to speak of the history of science) are two, Time and Space. These must certainly appear to science more fundamental than the remaining four, because they are capable of being treated as abstractions existing independently of the rest, while Matter, Number, Force, and Motion, are not capable of a similarly independent treatment; since either time relations alone, or time and space relations together, are involved in even the most abstract conception under which any of them can be presented as an existent object to thought.

Now it is impossible to think of an inseparable element of perception at once as existing and in complete isolation from its co-element or co-elements. To suppose the isolation perfect is to suppose the perfectly isolated element vanishing from the field of possible experience. But Time and Space are, in the ways we have seen as proper to each, inseparable elements of perception. The limit of abstraction in the case of time would be Eternity, that is to say, duration without content, and therefore without limit, except the present moment of experience from which we start in thought, and which serves as the minimum of content requisite to keep eternal duration before us

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at all, as a definite idea. In the case of space, the corresponding limit of abstraction from content would be reached in the idea of total Vacuity, infinite for a similar reason. But this idea can be conceived only by going through a process of abstraction from filled or differentiated extension, and then only so long as we retain some reminiscence of that differentiation, wherewith to contrast it. We start, in conceiving it, from a given or assumed point in space, and then conceive it extending from that point in all directions. More will be said, later on, of the way in which both these ideas of vacuity and eternity arise. But from what is now said it follows plainly, that it is impossible to suppose either Time or Space to be real existents, unless they are thought of as retaining some trace of their material co-elements of perception.

Now in this way it is, that they are thought of as really existing by science. That is to say, Time is taken by mathematicians and physicists as something that "flows equably," called by Newton "absolute time"; which completely negatives the notion, which sometimes seems to commend itself, that time in its totality, which may be called Eternity, can be regarded as a sort of linear receptacle for movements or events which flow through or take place in it, while it is itself stationary, *ἑστὼς ὁ αἰών*. The unique peculiarity of time is, that it involves duration from a former to a latter *in time*, which shows that it is an ultimate feature in experience, undefinable by anything but itself, that is, by terms in which its own nature is taken as known.

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On the other hand it is by no means implied by the equable flowing of absolute time, that time flows on separately from, and as it were alongside of, other things which flow on also, though less regularly, or perhaps occasionally stand still. Time taken *per se*, or in the abstract, is nothing but the fact of duration from a former to a latter in time, in all things whatever (except pure divisions of itself), abstraction being made of differences in length of the durations occupied by particular time-contents, or, what is the same thing, in the rate at which particular contents change or flow; since it is only by changes in the time-content that time-duration itself is rendered empirically perceptible, or the idea of it conceivable. Consequently, what is meant by absolute time flowing equably is neither more nor less than this, that we conceive it as divisible ideally into lengths of duration which are exactly equal to each other. And this divisibility is the trace retained by Newton's "absolute time" from its material co-element, enabling it to be apprehended as an existent.

Newton's "absolute space" also must be similarly understood, that is to say, as something different from total vacuity, since we find him saying, that it "*semper manet similare et immobile*," and is the same as relative space "*specie et magnitudine*," though not always "*numero*," inasmuch as the space occupied by one body relatively to that occupied by another may remain the same, while it may occupy first one part, and then another, of absolute space.[1] It is clear from this, that even "absolute

[1] See the *Scholium* appended to the *Definitions* of the First Book of the *Principia*.

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space" is conceived as figurable, in being conceived as comparable to "relative space." Now the lowest or most abstract degree of figuration, applicable to space in its entirety, is that given by the three Cartesian rectangular axes of co-ordinates, cutting each other at a single point, which have been already mentioned in Book I;—a figuration which is by no means adverse to the infinity of space, any more than the position of any present moment of time, between the two infinites of past and future, is adverse to the infinity or eternity of time.

We see, then, that concrete matter is not the only thing which at once is common ground to philosophy and science, and receives a different analysis from each. Time and Space, which are what I have called the formal element in the perception of objects, including matter, are in the same case. All three are numerically identical, but analytically different, in science and in philosophy. It is this fact of difference in identity of their object-matter which enables science and philosophy to exist in harmony, and mutually support and supplement each other. And this fact it is the business of philosophy to establish, simply because it occupies the more central and commanding position of the two, and the only position from which both procedures can be discriminated and compared, as was set forth more fully in an earlier Chapter.

At the same time it is only with the comparatively few fundamental conceptions of science that philosophy has to do. These it is bound, if possible, to bring into harmony with metaphysical analysis, thereby establishing the true relations

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which obtain between the two pursuits, and showing what use they may legitimately make of each other's results. The establishment of the difference in identity of their common basis implies that each must go its own way in building on that basis, according to the different analysis given of it by each. It is not for philosophy to re-write Euclid, construct vortex-atoms, weigh the ether, or trace the forces which pervade it, define Life, analyse neural energy, or discriminate from it the activity of an immaterial agent. The conceptions, problems, methods, and results of the two pursuits are all different, notwithstanding that the self-same experience is the object-matter and the source of both. I need hardly say, what will be obvious enough to scientific readers, that I have no pretension to write as an expert in any mathematical or physical science. My purpose in writing is merely to show how their fundamental conceptions harmonise with those of philosophy, originating, as they do, in the same experience differently treated.

When science objectifies material existents separate one from another in space and in time, it is evident that this carries with it the necessity of separately objectifying time and space also, as the media in which the material existents have their being and operation. And this separate objectification of what are originally and essentially inseparable formal elements of perceptions involves a duplication of them in thought, which may be the source of much perplexity. For perceptions do not cease to have duration when we objectify duration as a medium in which perceptions exist and change; nor do visual and tactual perceptions

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cease to be extended, when we objectify space as the medium in which visible and tangible objects exist and move. Thus we have to be careful not to confuse the duration, or the space, occupied by perceptions, or by material objects, with the duration, or the space, in or through which, as media, they are said to change or to move.

For instance, when a body moves, it seems to carry with it that portion of space which it occupies, and yet at the same time to leave behind it an equal portion of now empty space; that is, the same portion of space seems both to move onwards and to remain stationary. This appearance, and the confusion of thought which it is liable to cause, are due to the separate objectification of space as a medium. But no confusion need be caused if we remember, (1) that time and space are not really duplicated by our separately objectifying them, and (2) that, when they are so objectified, they are *eo ipso* considered as wholly independent of the occupation or non-occupation of any of their parts by perception or by objects, and offer no resistance or hindrance whatever to any changes of content which take place within them. Thus the space occupied by a moving body just spoken of is successively and numerically identified, as the body moves, with different portions of space taken separately as a medium; or in other words, different portions of space as an independent medium become successively the portion occupied by the body as it moves. Thus pure or abstract time and space, objectified as separate existents or media, are images partly due to conceptual thought,

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additional modes whereby we represent more completely the one really existent durational and spatial panorama.

But since time and space really exist in the material things, as well as between and around them, and since moreover the divisions, which differences in content introduce into time and space, are a means whereby ideal divisions can be introduced into them by thought, such as mathematical instants of time, mathematical points, lines, surfaces, and angles in space,—it follows that these ideal divisions may be made a means of measuring material things and their operations, as well as of measuring ideally time and space themselves as objective media. Exact measurement is the first and indispensable step towards the ascertainment of physical processes of every kind. From which again it follows, that pure geometry forms a sort of statical Logic of physics; and, founded upon geometry together with the notion of time-duration, Kinematic, the science of physical motion, abstracting from the question, what kinds of physical force are employed in producing motions, forms as it were the vestibule, first to Dynamic, and then to the still larger and more complex science of Energetic, which covers (in conception at least) all the forces of Nature, when these are apprehended as in actual concrete operation, or as Energies of several kinds.

The fact of motion in the world of space and matter, though we may abstract from its connection with force, cannot be separated in thought from the facts of time and space, so soon as we draw Newton's distinctions above mentioned, between

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absolute and relative time, and between absolute and relative space. Four things are mentioned in that *Scholium* to the *Definitions* of the First Book of the *Principia* already cited, to which the same distinction applies. The other two are absolute and relative Place, and absolute and relative Motion. And the definitions of the two kinds of place, and the two kinds of motion, are closely dependent upon those of the two kinds of space. "Place," says Newton, "is a part of space." The place of a body is the part of space which it occupies. And this is absolute if taken in absolute space, relative if in relative; "*pro ratione spatii, vel absolutus vel relativus.*" Upon this depend the definitions of the two kinds of motion. "Absolute motion is translation of a body from one absolute place to another; relative motion its translation from one relative place to another."

Thus we see that figured space, motion, and direction, rate, and duration of motion, are conceptions which hang closely together, mutually involved, and as a whole may very well be treated in abstraction both from the kinds of Matter and from the kinds of Force, in which they occur, or upon which they depend. So treated they form an introduction to Dynamic, and have received the name of *Kinematic.* "We adopt," say the authors of a well known Treatise on Natural Philosophy, in their Preface, "the suggestion of Ampère, and use the term *Kinematics* for the purely geometrical science of motion in the abstract." They devote to it in fact the first Chapter, occupying 200 pages, of their great work.[2] The same course is followed

[2] *Treatise on Natural Philosophy*, by Sir William Thomson (Lord Kelvin), F.R.S., and Peter Guthrie Tait. 2 vols. Cambridge. New Edition, 1879.

by W. K. Clifford, in his *Elements of Dynamic*, left unhappily incomplete.[3] Book II. Ch. I.

§ 5. Number.

§ 5. There is another science necessary to exact measurement, and perhaps the most elementary of all, which has still to be mentioned, the science of Calculation. This also has its root in perceptual data, though in a manner very different from geometry and kinematic. Its root percept is that of Number, a percept acquired indeed by means of conception, but acquired from perception simply, not necessarily from the complex perception of an external or spatial world. However obviously objects may be offered to perception separately, as for instance a tree, a mountain, a flash of lightning, a thunderclap, the stars, the five fingers of the hand, and so on, yet they are only recognised as units, that is, counted, by an act of attention noticing the fact of their separation from their context. Some perceptual difference is necessary to originate the perception, but it need not be more than such a difference as is necessarily involved in perception itself. Man must in fact have learnt to count, before reaching the perception of such complex objects as are several of those just enumerated, that is to say, during the process of learning to perceive them as single objects, a process which has been already analysed in Book I. Number is therefore entirely independent of spatial extension, so far as what is essential to it is concerned; though it is also evident that, when the mode of attention called *counting* has become habitual,

[3] *Elements of Dynamic*. Part I., *Kinematic*. Two vols. 1878 and 1887. Macmillan.

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there is no content of consciousness to which it cannot be applied.[1]

Counting the number of given empirical and discrete objects, such as the successive sounds of a bell, or a flock of sheep, or a heap of coins, means observing whether, for every act of counting *one* on our part, there is or is not, in the series or the aggregate to be counted, a single definitely marked object to correspond. In other words, it means observing the correspondence of the series or the aggregate, in point of number, to some abstract number which is known and recorded by a name or symbolic figure, and which has become part of the furniture of memory previously to being used as a standard of number for the given discrete and empirical objects which are counted by means of it. Moreover it must be noticed, that it is only similar objects which can be counted together in this way; that is to say, we must abstract from their differences in point of kind, before we can count them. Say, for instance, that the flock of sheep consists of white sheep and black sheep. To count the flock, we abstract from this difference, just as in

[1] On the point that number is not necessarily dependent on space-perceptions, I am glad to find myself in accordance with my friend M. F. Pillon, in that valuable series of articles entitled *À propos de la Notion du Nombre*, which he contributed at intervals to different Nos. of *La Critique Philosophique*, from June 1882 to Jan. 1885. See particularly No. 25 (*Douzième Année*) 21 *Juillet*, 1883, and No. 27 (same year) 4 *Août*, 1883. The persons must be few who could read these closely reasoned articles without instruction and profit. They are besides recommended to English readers by containing much acute criticism of the views held by J. S. Mill, Dr. Alex. Bain, and Mr. Herbert Spencer, on the subject of our perception of sequence and co-existence. Nevertheless I am unable to accept the theory of the distinguished author as a whole, since I find myself at variance with the initial assumption which he lays at its basis, namely, that our perception of Number is partly but essentially due to an *a priori* idea or form in the mind, which he calls a Category, and to which he attributes a similar nature and an equal rank with those *a priori* forms, ideas, or categories, from which he holds our perception of space positions and time successions to be ultimately derived. See more particularly No. 39, for Oct. 27, 1883, pp. 202—203, and pp. 206—207. M. Pillon, in fact, is strictly faithful to that modified form of Kantianism, which owes its being to the powerful mind of M. Ch. Renouvier.

counting either the white or the black, we abstract from differences which distinguish one white sheep from another, and one black sheep from another. So also we may count the sounds of a bell and the sheep of a flock together; but only on condition of abstracting from their differences, and treating them simply as so many separate percepts or experiences. Sameness of kind in the objects to be counted is therefore a condition of their being counted at all, that is, of their being compared, in point of number alone, with the scheme or series of abstract numbers, which we bring with us when we count them.

The first question, therefore, with regard to Number is, how originally, or in the first instance, we obtain the idea of number or numbers in the abstract; what is the meaning of the word *one*; or what the origin of counting or numbering, previously to applying it to count given empirical and discrete objects, of which we know beforehand that they exist in some number or other. For it is Number in this strict and abstract sense, not Number as exemplified by given empirical and discrete objects, whether in time alone or in time and space together, which is the object-matter of Calculation. Nothing is given to us in original experience ready counted. Differences in perception are originally given, and are ultimate data of perception and of experience; but we have to count them for ourselves, and count them after having observed them as differences, and perceptions as differents. In what, then, does counting originally and essentially consist? How come we in the first instance to speak the words *one*, *two*,

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three, and so on, with a meaning; or again, as we may also express it, to notice the fact of number in perceptions?

Now apart from the source just mentioned, namely, differences in perception, there is but one other positively known source from which counting or numbering can spring. It is the act or acts of attention to differences in perception, or to perceptions as different, with a view to knowing more about them than the simple perception of them as different tells us. It is an act the same in point of kind as that in which conception and logical thought originate, namely, the act of selective attention for the purpose of knowing something more of an occurring content of consciousness, (though of course neither the act nor its purpose are recognised as what they are, in the earliest instances of their performance). It is therefore subject to the same ultimate law of thought as the act is in which thought originates; namely, the law of which the so-called Postulates of Logic,—Identity, Contradiction, and Excluded Middle,—are the expression. The difference is, that, in the act of counting or numeration, the attention is directed, not to a sequel generally, whatever it may be, not to similarities or dissimilarities of any or all kinds in the content next to be experienced, but solely to one single kind of circumstance in that content, namely, the place in the time-stream of consciousness which different contents will occupy, abstracting both from the particular nature and the particular duration of those contents.

The act which originates numeration, therefore, though identical in kind with the act which origi-

nates conception and thought, is not co-eval with that act, but on the contrary presupposes it. Acts of conception and thought, with their content, but in their simplest shape, are its object-matter, are the experiences in which it for the first time observes the feature, or the fact, that they are divisions of the time-stream, and modify its course; or in other words, are the experiences of which it first observes explicitly, that they contain (unobserved by themselves) the distinction of one part of the time-stream from another, and in fact break it up ideally into different portions, irrespective of the kind or quality of the contents belonging to those different portions. This attention to acts of thought in their simplest shape, with conscious abstraction from the qualities of their contents, is the act of counting or numeration in its simplest shape; is the act in and by which counting or numeration originates, and the words *one*, *two*, *three*, *etc.*, are first uttered as the expression of a meaning. It is itself an act of thought, but it is not an act of thought in its simplest shape. It is an act supervening upon acts of thought in their simplest shape, an act of attention perceiving them as abstract divisions of the time-stream, apart from the differences in the quality of the contents which thereby they also divide.

In numeration, therefore, the acts of dividing the time-stream of consciousness, abstracting from all particular differences in its content, are that to which we attend, or in other words are the things counted; and thus these acts and the order in which they occur become themselves the units with which Calculation is originally and essentially con-

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cerned. These acts, it must be noted, are not acts of attending simply to differences between single discrete percepts, or between any of these and series or aggregates of such percepts, or between different series or aggregates of such percepts, as given in perception alone with intervals between them. I mean differences such as those, for instance, between the sound of a bell heard singly and two sounds of a bell, or any larger number, heard in near succession to one another, or again between, say, four and five such sounds heard in the same way. Acts like these, taken alone, that is, as distinguished from acts of applying numbers already acquired, to count given series or aggregates, a case spoken of above, are no acts of counting. They are acts of registering and naming single discrete percepts, or series or aggregates of discrete percepts, by the momentary impression of sameness produced by them; so that a series or aggregate which we called *four* on one occasion we might call *five* on another, without any certainty that *four* and *five* were not names equally applicable to the same series or aggregate, and therefore identical with each other in meaning. Acts of this kind could never become the basis of an exact science, since they afford no single unchanging perception, from which to frame an universally applicable definition.

The only true and originating act of counting is the act of attending, not to perceptions simply, but to a previous act of attention which has already singled out some percept or other, with a view to further experience, and has thereby introduced a division into the time-stream, which would not

have been perceivable in the time-stream without it. Thus selective attention to the time-stream is the first and fundamental act in counting, an act of thought simply; selective attention to that act, solely as a division of the time-stream, is the second and characteristic act, the supervening of which on the former is the act of counting or numeration proper; the existence of order or sequence in the divisions noted being due, not to the acts of attention whereby they are noted, but to that ultimate fact of consciousness, the union of duration with change, which makes us characterise consciousness as a time-stream.

But in thus abstracting from everything but the acts of dividing the time-stream, and the place of those acts in order of sequence relatively to one another, the second act of selective attention, which completes the original perception of numerical units, and is the first act of counting proper, also, and *ipso facto*, returns them, so to speak, to the perceptual order, or order in time, out of the conceptual or logical order in which the first act of selective attention momentarily placed them, by enabling them to be cognised as similars falling under the general head of divisions of the time-stream, or numerical units. Every such act or unit is thenceforward a single or individual perceptual representation, or represented percept, distinguished only by its place relatively to others of the same kind in a represented time-stream, named or otherwise noted only from the place it occupies in the represented series to which it belongs, and having a value depending only on that place, that is, on the number of units (otherwise undistinguish-

able from each other) which must first be represented, or thought of as represented, in order to arrive at it. We cannot originally, or in the first instance, count 2, without remembering the act of counting 1, and referring the second act to the first, which alone gives the meaning *two;* and the same is true with regard to 3 in relation to 2, with regard to 4 in relation to 3, and so on, so far as we can go in counting.

Acts of counting are thus, when objectified, themselves the units counted,—a thing only possible because consciousness is reflective as well as forward-going,—and therefore every number has a double character, one as a counting, one as an unit counted. Objectified as an unit counted, it is *ipso facto*, for a reason presently to be assigned, taken as a quantity, that is a complete object of representation, continuous *ad intra*, in which form and matter of perception co-exist, though without any specification of the mode of feeling, or quality, of that quantity, other than the fact of its having been distinguished from other units or groups of units, by an act or acts of counting, that is, by its place in a series. Objectified as an act of counting, it is nothing more than the operation itself, single in point of kind, by which all numeration is effected, that is to say, an operation taken in abstraction from the place in the series, or value of the quantity, which is counted by it.

This fact of the double character inherent in every number, each character being distinguishable and objectifiable apart from the other, a fact which helps to explain many apparent inconsistences, we may see exemplified by comparing together the

fundamental operations of arithmetic. In addition and subtraction we attend to the units as already counted, and as having each its place and consequent value in the series of units spoken of, but with abstraction from the acts of counting by which that place has been assigned them. In multiplication and division, on the other hand, the units counted are either taken in this same way, in which case multiplication and division are merely the abbreviation of processes of addition and subtraction; or they are taken as identical with the acts of counting them, the acts which originally assign them their place and value in the series.

As for instance in multiplication, $1 \times 1 \times 1 \times 1 \times$ &c. is always and for ever 1; meaning that the number of times we count 1 never makes it anything but one; or that the unit 1 and the act of counting 1 are the same in point of kind, nature, or meaning; which way of taking it answers to the A is A, or Postulate of Identity, in Logic. And the same in division, where 1 divided by 1, or $\frac{1}{1}$, is always 1; a process which has the same signification. Any number, say 1000, counted once, that is, multiplied by 1, is always 1000, no matter how many times you may count it. Again, multiply it by 0, and it is annihilated; 0, or zero, here meaning, that the act of counting it is denied, whereby it is reduced to non-existence as a quantity. So in division, any number, say 1000, compared once with itself, that is, divided by 1, is always 1000, however many times you may repeat the comparison. Dividing it by 0 means, on the other hand, giving it an infinite value, inasmuch as it differs from what as a quantity is taken as its

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measure by the whole difference between existence and non-existence.

If, on the other hand, we take the times or acts of counting, or otherwise dealing with given numbers, as themselves being or consisting of units already counted, then the processes of multiplication and division become simply, as already said, more compendious methods of addition and subtraction. To multiply 1 by 6 is then simply to add 1 to another 1 six times, or to move 1 from the first to the sixth place and value in the series of units already counted. Conversely to divide 1 by 6 is to divide 1 into 6 parts, or lesser units, equal to each other, and to subtract five of those parts, *i.e.*, all but one, from the resulting number, which thus becomes one sixth part or fraction, $\frac{1}{6}$, of the originally given unit. Fractions are in fact units, only of a lower order than the units with which we begin, namely, integers. In obtaining them, an integer is treated as divisible, and therefore (although it may be an unit) as a continuum. And here again the same phenomenon meets us; I mean, the act of dividing an original unit, or integer treated as an unit, into fractional parts, say 6, involves, first an equal number of acts of counting, that is 6, and then the act of recognising them as together constituting the unit divided. Each of the six one-sixths is an unit (though of a lower order) because it corresponds to, and is originally the creature of, a single act of counting. Every single original unit taken as a number counted, is thus divisible into an indefinitely great number of lesser units, called fractions, the number of which increases, and the magnitude of which, taken severally, decreases, in

proportion as higher values are given to their denominators.

From this we see, that it is only when units are taken as identical with acts of counting which have different places in the time-stream, as they are in the first counting or construction of the series of integers, 1, 2, 3, 4, . . . &c., 2 meaning two successive acts of counting, 3 meaning three successive acts, and so on, that they can be said to be equal one to another; the fact being, that they are then taken with all difference abstracted from, save only that difference of place in the series, from which all difference in value, that is, in magnitude as *quanta*, is derived. This seems to be the true solution of the dictum wherewith Kant puzzled his contemporaries, to the effect, that the expression $7 + 5 = 12$ was the expression of a synthetic, not of an analytic process. The simple fact is, that we construct the series of numbers in and by analysing, that is in this case, dividing, the time-stream. Acts of counting, being acts of thought, are, like all acts of thought, at once analytic and synthetic; analytic of the time-stream of consciousness which they perceive in retrospection, and the moments of which they count and name as it recedes; synthetic as successive moments in psychological forward-moving processes belonging to the time-stream itself, which is constantly adding new contents to those already perceived. It is thus quite true, that you cannot analyse 12 into $7 + 5$, until you have first counted up to 12, going through 5 and 7 on the way. The original process of counting, which is both analytic and synthetic of the time-stream, is purely synthetic of the number 12. It is

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only in an additional act of retrospection that we recognise its analysis into the 12 successive moments of the process of counting it, which nevertheless is analytic, as well as synthetic, of the time-stream, and purely analytic so far as its element of thought is concerned. If numbers are the offspring of thought out of perception, they are originally obtained by analysis of perception, but not by analysis of numbers. Their analysis as numbers comes in, when we see each successively counted number in retrospect.

For numbers, that is to say, the units or structures of units thus produced and counted, taken as data, or objects of thought furnished by this double process, are themselves liable to be recalled in thought, and to have their numerical relations to each other, as such data, examined and ascertained. It is thus that they fall into different orders, as we saw above in the case of a fraction obtained by division of an integer. To ascertain the relations of numbers, of all possible orders or kinds, to each other, taken as data or realities having laws of their own, is the whole business of Calculation as the pure science of Number, apart from its application to the measurement of quantities other than number or numbers themselves. In fact a number is itself a relation. Any whole number may be expressed as a fraction whose denominator is 1. The meaning of it as a whole number is its relation to 1; or in other words, its place in the series of whole numbers, and therefore its value, consists in its relation to unity. Thus Unity is, as it were, the pivot upon which the whole science of calculation turns, inasmuch as it

is that act, or that number, in which the act of counting and the thing counted coincide or are identical.

This consideration brings us to that reason promised above, for the fact that, in objectifying acts of counting as things counted, we treat and cannot but treat them as continua. The case stands thus. When by attention we make that division of the time-stream of consciousness which we call counting 1,—and it is plain that, without some content of consciousness to divide, no division is possible,—we distinguish the moment of time which precedes, from the moment which follows, that division; these two moments of time being continuous with each other, save for that ideal division which our act introduces, and which as due to an act of ours we call ideal, and consider as itself occupying no duration in the given time-stream, since to suppose that it did would be to falsify given fact by an assumption of our own.

In the first or rather the simplest act of counting 1, there are, therefore, three things at the least, inseparably connected; the two continuous moments of time, and the ideal division which renders them discrete, that is, distinguishes without separating them. And the same remark holds good for every single act of counting 1, after the first; that is, for counting 2, or $1+1$; 3, or $2+1$; 4, or $3+1$; and so on. We cannot separate, except by a further abstraction, the act of counting 1, whenever it occurs, from the time-portion or thing counted, which is distinguished as one thing by that act. The act of counting, therefore, is an act which distinguishes or counts the first of the two continuous moments just spoken of, which at the

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instant of counting is perceived in retrospect, as *one*, and the second of those moments, which at that same instant is perceived in anticipation, as *two*; *two* being the name which characterises it solely in relation to *one*; and the act of counting itself, to which the distinction is due, being recognised as an act of counting only by a subsequent reflective perception of the process in which it is involved, and of which it is recognised as the essential or characteristic ingredient, and not as forming a third thing counted.

Thus by way of illustration, suppose it is 12 o'clock on Sunday night. At that instant, I count Sunday in retrospect as day *one*, and anticipate Monday, which begins at that instant, as day *two*, which nevertheless will not have become a whole day, till I can count it also in retrospect, at 12 o'clock on Monday night. The act of counting, that is, of distinguishing Sunday as one, Monday as two, introduces an ideal division or limit, which itself has no duration, between the two days, and is called 12 o'clock on Sunday night. There is no such ideal division or limit of time-duration in Nature, as distinguished from my act of counting; there is only the continuous revolution of the earth on its axis, exposing portion after portion of the earth's surface to the sun's rays, a process into the representation of which I introduce an ideal division or limit, for purposes of calculation and measurement. "*Neque novit Natura limitem*" is Newton's no less profound than accurate remark, when speaking of the application of this same process of counting in the Differential Calculus.[2]

[2] In the *Scholium* to Section I., Book I., of the *Principia*.

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Abstract acts of counting are thus always and necessarily acts of dividing a continuum of some sort or other, whether of pure duration (as in pure calculation), or of spatial extension (as in geometry), or of both together (as in the case of motion), or of some other content common to both (as in the case of force, intensity, and energy), by ideal limits or boundaries which have no duration or extension themselves. It is on our power of doing this, in studying the concrete phenomena of Nature, whether these are physically continuous or physically discrete, that the exact physical sciences depend for their exactitude. The distinction, therefore, between the abstract act of counting, or introducing into given continua ideal divisions which occupy no portion of those continua, and its results, namely, the portions of continua which are distinguished from one another and counted or measured thereby,—this distinction must be carefully drawn and observed. Numbers have no real existence, save as the recorded results of such acts.

Hence, when we come to objectify acts of counting, we can do it in two ways. If, first, we objectify them as abstract acts, we find that they are all alike,—there is one nature common to them all,—there is the (general) act of counting *per se* as distinguished from the numbers counted, whatever these may be, and we have a purely logical entity before us, the particular instances of which are undistinguishable from one another. But if, secondly, we objectify them (though distinguished only by abstraction) as they actually exist or have existed, and in distinction one from another, each as a particular act,—then we find that we do and

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can make this distinction only by taking each as embodied in, or represented by, the particular number to which it gives rise, and which is its inseparable result. Each number or modification of number will then represent a particular act of counting in relation to a series of others, on which it immediately depends; and its place in that series or system of numbers to which it belongs is the only means we have for recording and distinguishing the act of counting which gives rise to it, from the endless series of acts of counting, of which, being otherwise undistinguishable, memory refuses to retain a separate trace. That is to say, any act of counting, when taken as an unit counted, is *ipso facto* identified with that particular portion of the continuous time-stream which it serves to count, and from the place of which in the time-stream it derives its value as a quantity.

We come back, then, in the last resort to Numbers, and in the first instance to the series of whole numbers of Integers, as the basis of the whole science of Calculation, and through calculation of Measurement,—since there can be no measurement of one thing by another, without first distinguishing two things from one thing, that is, without counting. But, as we have seen, all Numbers are continua; that is, cannot be distinguished one from another save by taking them as continuous portions of one and the same continuum, only rendered discrete one from another by the abstract act of counting, that is, of ideally dividing (without occupying) that continuum. Discrete quantity is continuous quantity broken up, or considered as broken up, into smaller

continua, a process to which there is no assignable limit. Number itself is discrete quantity in this sense. I think there is no avoiding this conclusion, unless we assume, that an Absolute Logos of some sort or other creates itself and the universe, by means of some immanent pseudo-action and re-action between the logical principles of Identity and Contradiction,—an idea which would be strange if true, besides being unintelligible whether true or not.

At the same time, several things must be remembered. First, in forming any series or system of Numbers, the particular nature of the continuum, of which they form part, is abstracted from. We have seen that, as a fact, Time is the one continuum which is indispensable to the process of counting. But a knowledge of this fact is not included in the nature of Number, considered either as the means, or as the object of Calculation. Time is not the object measured by a simple succession of acts of counting, the intervals between which are wholly arbitrary, so far as their length is concerned. Similarly, the psychological act of purposive attention to a content of consciousness is indispensable to counting, and therefore to Number. But this act in its psychological character lies wholly outside the process-content of calculation as such. Its duration as a psychological act is not in question at all. If either time or the act of attention is made an object of measurement or calculation, it must be by way of first objectifying it as a particular object among others. Number, in short, though arising solely from the ideal division of a continuum, by means of a

psychological act which has duration, is no measurement either of the continuum or of the act. Yet there is an object which it measures, and therefore a sense, and that the most essential to it, in which it is measurement; the object which it creates is the object which it measures, namely, number itself, by means of the first result of its fundamental and perpetually repeated act, the act of counting, that first result being Unity, or the number One. Number (as a general term) means a number of Units. In other words, the standard of measurement in all calculation is Unity, being that determination in which the act of counting and its result coincide. This circumstance it is, which gives Calculation its specific character among all other modes or sciences of measurement.

Let us see more particularly how this can be. In ideally dividing the time-continuum by the first act of counting, we look back at a portion of that continuum which is undetermined as to its beginning, and forward to another portion of it which is undetermined as to its end. In the second act of counting we determine the end of this latter portion, look back upon it in retrospect as a portion whose beginning is already determined by the first act of counting, and forward to another portion whose end is as yet undetermined. In the third act of counting the same process is repeated, and so on for as long as we can continue to count. Thus, as we advance, we continue to lay behind us in memory a series of acts of counting, each of which determines the end of one portion of the time-continuum and the beginning

of another, the continuum itself being otherwise undivided, that is, undetermined as to the length of any portion of it, save by the successive acts of counting, which may themselves take place at quite arbitrary and variable intervals.

Yet at the same time, the perception of the time-continuum itself cannot be avoided or dispensed with. For, if there were no interval perceived between the successive acts of counting, they could not be perceived as several or successive ; there would be no possibility of remembering or recording a first act when performing a second, or a second when performing a third, and so on. Time-intervals are therefore necessary to a succession of acts of counting, that is, to Number, and yet there is no measure of the length of those intervals, save the remembered or recorded number of times for which the successive acts of counting have been performed. Consequently the interval or difference between acts of counting, that is, between successive numbers, 1, 2, 3, &c. (as well as every increase in the number of the acts themselves), is measured by 1. Or in other words, numerical Unity, a pure Number, is the measure of the interval or difference between 2 and 1, between 3 and 2, between 4 and 3, and so on.

When, therefore, taking Number at its origin, or in its lowest and simplest terms, we objectify it as the result of repeated acts of counting, we must consider it, like Time itself, as a continuously growing quantity, the successive increments of which are noted and recorded only by figures or symbols expressing the number of single acts of

counting which have gone to their discrimination, in which every single increment necessarily corresponds to a single act of counting, and is therefore necessarily equal to every other. For two ways, equally legitimate and equally necessary, are then open to us in which to objectify it. If in the first instance we objectify the several acts of counting *per se*, we get the series,

1. 2. 3. 4. &c.,

while, if we objectify this same series of numbers together with the continuum which they divide, what we get is the series of intervals,

$$0 \;\underset{1}{\text{—}}\,|\,\underset{2}{\text{—}}\,|\,\underset{3}{\text{—}}\,|\,\underset{4}{\text{—}} \;\; \&c.,$$

in which the same figures or symbols represent intervals between single acts of counting, and in which we supply, in thought, the starting point 0, the distance or difference of which from the first act of counting is determined by unity, that is, the same distance or difference which obtains between all the several subsequent acts of counting. Each interval is itself a number and nothing else, namely, the number *one*. And the result is plainly to transform, in thought, the original time-continuum discriminated by acts of ideal division into a purely numerical continuum, that is, a continuum in which there is no interval (but only an ideal division) interposed between the several discrete parts, called Numbers, of which it is composed. And Numbers thenceforward, for purposes of calculation, replace, and are the substitute for, that time-continuum and its ideal division by acts of purposive attention, which are the matrix out of which they originally spring.

Numbers henceforward appear, or may appear, as immaterial entities having an independent or solely self-dependent existence, with properties and laws of their own, relating them to one another, as if they were dwellers in some transcendental region, *sui generis*, far removed from the ordinary phenomena of spatial figuration, motion, and matter; while at the same time, being applicable to the measurement and calculation of those phenomena, they would seem to contribute a transcendental or purely *a priori* element to the sciences which treat of them, namely, pure geometry and the physical sciences. From this point of view it is possible to make Numbers the object of much quasi-scientific superstition. In reality they owe both their own nature, and their applicability in geometry and physical science, to the fact that they originate in the ideal division of the time-continuum by acts of purposive attention. The perceived fact of an ever divisible but never severable continuity, to which they owe their origin, is not lost, but only transformed, when they are themselves taken as forming a numerical, that is, a discrete but inseparable continuum of units; in which each unit, being itself a continuum, is again ideally divisible into smaller continua, or continua of a lower order as compared to the original series of integers, and these again into continua of a lower order still, and so on without assignable limit.

We now see the metaphysical justification for those elementary statements concerning Number, with which arithmetical treatises usually begin. I take the following from

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Newton's *Arithmetica Universalis, In usum Juventutis Academicæ:*

"By *Number* we intend not so much a multitude of unities, as an abstract proportion of any quantity whatever to another quantity of the same kind which is taken as unity. And number is of three kinds, integer, fract, and surd. An integer is that of which unity is the measure. A fraction is that of which a submultiple part of unity is the measure. A surd is that which is not measurable by unity." [8]

The question may here be asked, how, putting fractions aside, any number is conceivable, which is not measurable by unity. The answer seems to be, that Newton has here in view numbers which are named by general terms only, that is, named as the imagined results not actually realisable of certain processes of calculation, which processes, supposing (*per impossibile*) they could be carried to completion, would yield definite numbers, com-

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[8] *Arithmetica Universalis.* Cantab. 1707. p. 2.—"Per *Numerum* non tam multitudinem unitatum quam abstractam quantitatis cujusvis ad aliam ejusdem generis quantitatem quæ pro unitate habetur rationem intelligimus. Estque triplex; integer, fractus et surdus: Integer quem unitas metitur, fractus quem unitatis pars submultiplex metitur, et surdus cui unitas est incommensurabilis." I have been told that the most advanced mathematicians of the present day have ceased to regard Number as Quantity, and would no longer adopt Newton's conception of it in this passage. It is of course open to mathematicians to define Number in whatever way they find most suitable to the requirements of their own science. Still I must say that, looking at Number with respect to its origin in actual experience, and to the place which it occupies in that experience as a whole, I am at a loss to see how it can be referred ultimately to any other conception than that of Quantity, which embraces every possible kind of comparative magnitude, unless we suppose it to be a pure creation of some purely abstract Thinking Power, hypostasised as an agent by assumption, in which case it might no doubt be held to be a Quality, namely, a quality of the thought of the assumed Thinking Power. But this would be substituting assumption for experience. In all Newton's statements of elementary truths, so far as I can claim acquaintance with them, I seem to myself to recognise a mind which not only takes experience as its guide, but also keeps in view the relations which that part of experience, which he is at any time considering, bears to other parts and to the whole. This is a circumstance which renders his writings invaluable to the metaphysician.

mensurable with unity, as their result. Now since Algebra is that branch of the whole science of calculation which is based upon the generalisation of arithmetical numbers and processes,—every generalisation being expressed by some symbol, which enables it to be used in calculation *as if* it was a particular number, or particular kind of process,—and Newton is here treating the elements of arithmetic and algebra in conjunction, we must suppose him to have algebra chiefly in view, when he names surds as the third of the three highest kinds into which all number is divisible.

Surds arise in algebra in the process of extracting what are called the *roots* of numbers, which numbers are thereby *ipso facto* treated as *powers*; both *roots* and *powers* being used in algebra as general terms for the anticipated results of certain processes of calculation. By the Powers of a number are meant the numerical results which would be obtained by multiplying that number by itself for any given number of times; as *e.g.*, $2 \times 2 = 4$; $4 \times 2 = 8$; $8 \times 2 = 16$; and so on; where 4 is the second power (or square) of 2, written 2^2; 8 is its third power (or cube) written 2^3; 16 its fourth power, written 2^4. The inverse process to this is that of root-extraction. It consists in finding what number, multiplied for any given number of times by itself, will yield that given number, the square, cube, fourth, fifth, &c. root of which is required.

But here arises a difficulty, owing as usual with difficulties to an assumption, namely, to the assumption that every given number is a power. For although we have no difficulty in raising any

given number to any assigned power by a process of multiplication, it by no means follows that we can carry to completion the inverse process of extracting the root of any given number. This necessarily follows only in the case of those numbers which have been previously reached by the direct process. The idea that all given numbers are powers derived from roots, as well as being simply numbers, is arrived at by generalising from successful instances of root-extraction, and consequently expecting success in cases where only imaginary results are in reality obtainable. That the two processes are the inverse of each other in point of kind, does not show, that they are alike in being applicable to any given number.

In all cases of root-extraction, therefore, in which the given number, the root of which is required, is not known to be a power, we have before us, not a simple process of calculation, but a problem, the problem, namely, to find whether the given number has a root or not. From the fact of the problem being proposed to find the root of a given number, it does not follow that the required root can be found. For instance, "the number of exact squares is infinite; but there are within any assigned limits many more numbers *not* having exact square roots than there are of exact squares."[4] And in Algebra, to quote another authority, "When a root of an Algebraical quantity which is required, cannot be exactly

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[4] *Arithmetic for the Use of Schools.* By A. Sonnenschein and H. A. Nesbitt. London, 1870. Part III., p. 216.

obtained, it is called an *irrational* or *surd* quantity. Thus $\sqrt[3]{a^2}$ or $a^{\frac{2}{3}}$ is called a surd."[5]

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Coming, then, to the second and by far the most extensive and important branch of the whole science of Calculation, namely, Algebra, using this term in its widest sense, we find the first paragraph of Newton's *Arithmetica Universalis* running as follows :

" Calculation is effected either by numbers, as in common Arithmetic, or by symbols with a general signification (*species*) as practised by Analysts. Each kind rests on the same foundations and aims at the same end ; Arithmetic definitely and particularly, Algebra indefinitely and universally. So that, broadly speaking, all enunciations used in algebraical calculation, and especially its conclusions, may be called Theorems. But the chief excellence of Algebra consists in this, that, whereas Questions in Arithmetic are solved only by going forwards from quantities given to quantities sought, Algebra for the most part goes backwards from quantities sought, taken as if they were quantities given, to quantities given, taken as if they were quantities sought ; in order to arrive, by whatever means, at some conclusion, or *Equation*, from which the quantity sought may be elicited. In this way the most difficult Problems are disposed of, the solution of which would be attempted in vain by Arithmetic alone. Nevertheless, Arithmetic so subserves Algebra in all its operations, that both together constitute a single perfect Science of calculation ;

[5] Todhunter's *Algebra*. Fifth Edition, 1870, p. 157.

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for which reason I propose to expound both together in conjunction."[6]

There are some points in this passage which seem to call for elucidation. The term *species* I have paraphrased rather than translated by 'symbols having a general signification,' *general* being the term of ordinary logical thought, which most nearly corresponds to what, in purely quantitative thought, is expressed by *indeterminate*. The meaning of species is presently given by Newton himself as equivalent to the letters used to stand for quantities which are either unknown or are regarded as undetermined. "When the quantity of anything is unknown or is regarded as undetermined (*indeterminate spectatur*), so as to be left unexpressed by numbers (*ita ut per numeros non liceat exprimere*) our usage is to designate it by

[6] Work cited, p. 1.—"Computatio vel fit per numeros ut in vulgari Arithmetica, vel per species ut Analystis mos est. Utraque iisdem innititur fundamentis, et ad eandem metam collimat: Arithmetica quidem definite et particulariter, Algebraica autem indefinite et universaliter; ita et enuntiata fere omnia quæ in hac computatione habentur, et præsertim conclusiones, Theoremata dici possint. Verum Algebra maxime præcellit quod cum in Arithmetica Quæstiones tantum resolvantur progrediendo a datis ad quæsitas quantitates, hæc a quæsitis tanquam datis ad datas tanquam quæsitas quantitates plerumque regreditur; ut ad conclusionem aliquam, seu *Æquationem*, quocunque demum modo perveniatur, ex qua quantitatem quæsitam elicere liceat. Eoque pacto conficiuntur difficillima Problemata quorum resolutiones ex Arithmetica sola frustra peterentur. Arithmetica tamen Algebræ in omnibus ejus operationibus ita subservit, ut non nisi unicam perfectam computandi Scientiam constituere videantur; et utramque propterea conjunctim explicabo."—Here again we find no less an authority than Auguste Comte blaming Newton for defining Algebra as *universal arithmetic*, on the ground that it gives a very false idea of the real relation between the two sciences, and one which Newton himself would be among the first to reject at the present day. (*Cours de Philosophie Positive. Quatrième Leçon.* Vol. I., p. 135. Littré's edition, 1864). Comte's own distinction between them is briefly summed up by saying, "que *l'algèbre* est le *calcul des fonctions*, et *l'arithmétique* le *calcul des valeurs*" (*ibid.* p. 134). But without for a moment denying the universality of pure arithmetic, which is at once the basis and the final end of all Calculation, I still cannot but think, that the distinction of method (*a quæsitis tanquam datis ad datas tanquam quæsitas quantitates*), signalised by Newton as characteristic of algebra, affords a clearer view of the position which the two provinces respectively hold to the processes of ordinary logical thought. Newton's distinction is especially valuable from its exhibiting the methods of arithmetic and algebra in this connection, that is, in the light of their common relation to thinking as a whole. That the distinction is a real one, that the inverse method of algebra is really a generalisation, as well as an inversion, of the method of arithmetic, will I hope become evident as we proceed.

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some *species* or letter (*speciem aliquam seu literam*). And in case we regard known quantities as undetermined, then we designate them for the sake of distinctness by the initial letters of the Alphabet, a, b, c, d, and unknown quantities by its final letters, z, y, x, &c."[7] And again, at p. 6, a, b, and x are given as instances of *species;* and ab, and abx, as expressions for the process of their multiplication one with another. Two distinct kinds of quantities, as well as those expressed by simply arithmetical numbers, can thus be dealt with in conjunction by means of these two classes of algebraical symbols.

From this we see what at the least must be meant by the brief expressions of proceeding *a quæsitis tanquam datis*, and *ad datas tanquam quæsitas quantitates.* We proceed 'from quantities sought as if they were quantities given,' when we designate them by letters which we can use as items in processes of calculation, as if they were known numbers; a proceeding which is only possible because they are indirectly given by means of those of their relations to other numbers or quantities, by which they are described in problems concerning them, and without which we should have no knowledge of them whatever. The symbols x, y, z, &c., are general terms describing any number which answers to a given description, or belongs to a given class, and which therefore, within that class, is susceptible of an indefinitely variable determination. The symbols a, b, c, d, &c., are also general terms applicable to classes, but are restricted to mean some deter-

[7] Work cited, p. 3.

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minate value which does not vary in the course of the calculation in process, though the particular value meant is left undetermined. Unknown quantities of the former class are called *variables*, those of the latter *constants*. It is from the relations given in this general way, that the required numbers or quantities themselves have to be discovered. And in doing this we *ipso facto* proceed 'to given quantities as if they were sought quantities'; namely, when we express the really given relations as resulting from calculations, in which the letters designating the unknown *quæsita* are employed.

The given relations spoken of, between numbers or quantities which are not themselves given but sought, relations which are implicit in the signification of the letters which stand for those sought quantities, are in Calculation what generalities or general descriptions are in ordinary thought, the science of which is Logic. They correspond to what are called "second intentions" in Logic, arithmetical numbers to its "first intentions." It is as if, in ordinary logical thought, we were given the relations expressed by the complex general term 'rational featherless biped' (to use the old instance for simplicity's sake), and required to find the individual creature corresponding to the description, namely, man. Or again, as if the term 'rational featherless quadruped' was given; in which case the required individual creature corresponding to the description, supposing he should not be forthcoming, would be analogous either to zero, or to a surd or impossible quantity in numbers, a quantity called imaginary because it

is not imaginable, that is, not realisable in thought, but continues as the expression for a process incapable of being carried to an exact conclusion.

Such processes from general conceptions to individual instances are fruitful in pure mathematical thought, because *ex hypothesi* it deals only with pure quantity discrete or continuous, and not with generalities of any kind whatsoever which may be produced out of the imagination by the *intellectus sibi permissus.* It has in its methods, restricted as they are to this object-matter, the means of distinguishing the true from the false, the thinkable from the unthinkable. Pure mathematic, like all exact science, of which it is the indispensable basis, deals with objects (using this term in the widest sense) only so far as they are either measurable, or can be tested in point of measurability.

We have already seen that arithmetic treats its numbers as complete and independent objects having different values in relation to one another, just as if they were so many atoms, molecules, or masses of matter, belonging to different kinds of chemical substances. Though they are products of thought out of perception, yet, as we have seen, thought immediately returns them again to the perceptual order, by conceiving every number as a logically singular and individual existent. The more complex or recondite laws of their combinations must be discovered, as in the case of real matter, by a further exercise of thought, that is, conception and reasoning. And this further exercise in the case of arithmetical numbers, which are the Realities of calculation, is Algebra, the method

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which is the generalisation of arithmetical method, bringing out explicitly all that in arithmetic is implied but undeveloped.

For while algebra generalises the numbers or quantities of arithmetic in the way we have just seen, it is necessarily led thereby to generalise, or rather extend the application of, its processes also, in a similar manner. It does so, for instance, when it uses brackets or vincula to denote that a complex quantity, which it may have created for itself out of the conditions of any given problem, and the value of which it has left numerically undetermined, is to be dealt with as a composite though single quantity; that is, a quantity in the algebraical resolution of which, prior to the resolution of the equation in which it stands, every single component is to be taken account of. As for example, in the expression $(a+b)^2$, the enclosure of $a+b$ in brackets, with the sign for its being raised to the second (or square) power attached to it as a whole, indicates that each of its components taken separately is to be multiplied once by itself, and once by the other component; so that we get the equivalence,

$$(a + b)^2 = a^2 + 2ab + b^2,$$

by which the elimination of one or more of its factors, by their balancing equivalents on the opposite side of the equation, is facilitated.

Again the ordinary processes of arithmetic are generalised in algebra, by using (1) the signs $+$ and $-$ as signs of processes contributing to some final result, irrespective of whether any real quantities exist which are to be added in the one case, or from which subtraction can be made in

the other, and (2) by using the signs × and ÷, the signs for multiplication and division, in the same way. Moreover rules are laid down for the use of both pairs of signs, first for that of + and −, and then for that of × and ÷, in application to + and − quantities. The latter rules briefly stated are, that + quantities multiplied or divided by + quantities, and − quantities multiplied or divided by − quantities, alike yield + quantities; and that + quantities multiplied or divided by − quantities (or *vice versa*) alike yield − quantities.

The reason for these latter rules will be evident, if we consider the necessity we are under, in calculating by means of variable and indeterminate quantities, of leaving indeterminate the results of processes which are indicated by these and similar signs (such as those for potentiation and root-extraction), until they can be seen as parts which together constitute the entire data of the calculation. For this necessity leads directly to what is perhaps the most fundamental generalisation in all algebra, which is implied in all its processes, and in the form which all its judgments take, namely, the form of an equation. I mean the general conception of negative quantities, that is, quantities which are less than nothing, and precisely so much less than nothing as the figures are higher which express them. The symbol 0, or zero, is then conceived as standing midway between two indefinitely great classes of numbers, one containing all numbers which are positive, or greater than zero, expressed by +, and the other containing all negative numbers, or numbers which are less than zero, expressed by −. And to the

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one or the other of these opposite classes every quantity which differs from zero must belong. In one sense, therefore, the zero value 0, standing between positive quantities on one side and negative on the other, occupies a position analogous to, and implied in, that occupied by the sign of equality, =, between any two quantities which differ from 0, irrespective of their place in these classes; seeing that such quantities are only equal when, on subtracting either of them from the other, the result is 0, that is, when no quantitative difference is found between them.

Now the rules of sign stated above for the multiplication and division of algebraical quantities, namely, that like signs yield +, and unlike yield −, may be considered as rules affecting them simply as operations, determining whether their results (which are *products* in the one case, *quotients* in the other) belong to the positive class of numbers written to the right, or to the negative class of numbers written to the left, of 0. I mean, that the quantities themselves have + or − signs affecting them, before we are directed to multiply or divide them, and that these signs must be kept distinct from those which their results will have, when those operations shall have been effected. The signs of these results it is which we want to know, without actually performing the operations directed by them, in order to establish those equations from which alone the numerical value of the results themselves can be ascertained. The question then is, what signs the quantities to be multiplied or divided one by another must have, previous to those operations, in order that the results of those

operations upon them should be placed respectively either among positive or among negative quantities.

And first as to multiplication. In the operation of multiplying one + quantity by another + quantity what we do is to count the multiplicand as many times as the multiplier has units. Both quantities being positive, the operation can only have a positive result.

But if either the multiplicand or the multiplier is negative, the other quantity being positive, the operation with its result will be negative. For suppose in the first place the multiplicand negative, say −6, while the multiplier is positive, say + 3, Then the sign of the multiplier is the sign of the operation, that is, we have a positive counting of −6 three times. Nothing alters the sign of 6. Consequently we have the result negative, −18.

Secondly suppose the multiplier negative, and that we have, say, to multiply + 6 by −3. The operation is here negative, that operation being the operation of counting. But what is it to count 6 for − 3 times? Consider it thus. If we counted 6 once, that is, multiplied it by 1, the result would be 6. If we said, we don't count 6, that is, if we multiplied it by 0, the result would be 0. If we counted it once less often than 0, we should be multiplying it by − 1, and the result would be −6. Similarly to multiply it by − 3 is to suppose it counted 3 times less often than 0, that is, to make t−18.

In both cases, therefore, of the multiplication of quantities with unlike signs, the result has the negative or − sign.

Lastly suppose we are multiplying together two negative or − quantities, the signs being alike but negative. This means, that we are either to count, say, − 6 for − 3 times, or − 3 for − 6 times. We have just seen what counting for − times means. In the present case, then, we have only to repeat the same reasoning ; and it is here of no consequence which factor is taken as multiplicand, and which as multiplier. Say we have to multiply − 6 by − 3, or count − 6 for − 3 times. Now, not to count − 6 at all, *i.e.*, to multiply it by 0, is to bring it up to 0, from being 6 less than 0 ; we simply, as it we, wipe out a debt. To count it for − 1 time is to bring it up to + 6 ; for − 2 times, up to + 12 ; for − 3 times, up to + 18. Consequently the result obtained by multiplying two negative or − quantities has a + sign, just as when two + quantities were multiplied together.

Turning next to division, the same rule holds good. The quotient will be positive if the signs of divisor and dividend are alike, and will be negative if they are unlike. The divisor is here the operative element, as the multiplier was in multiplication, the difference being that, whereas a multiplier expresses how many times a quantity is to be counted, a divisor expresses into how many equal parts a quantity is to be divided, or what is the same thing, how many times one of those parts must be counted, in order to be brought to equality with the whole. A dividend divided by a divisor yields its quotient ; and conversely a quotient multiplied by a divisor yields its dividend.

Here in the first place it is plain, that the process of dividing a + quantity by a + quantity can

never yield any but a + quotient, whichever we take as the divisor. Book II. Ch. I. §5. Number.

Secondly, supposing the dividend to be a − quantity, and the divisor a + quantity, then the quotient must be a − quantity, in order that, when multiplied by the divisor, it should, in accordance with the rule for multiplication, be equal to the dividend.

Similarly, supposing the dividend to be a + quantity and the divisor a − quantity, again the quotient must be a − quantity, in order that, by the same rule of multiplication, it should be equal to the dividend, when multiplied by the divisor.

So that, in both these cases, two quantities of unlike signs divided one by the other yield − quantities as their quotients.

Lastly, if we divide − quantities by − quantities, whichever we take as the divisor, here also, as in the case of + quantities, the quotient must be a + quantity, in order, by the same rule of multiplication, that, when multiplied by the − divisor, it should be equal to the − dividend.

All this is, I believe, nothing more than drawing out explicitly what is meant by saying briefly, in justification of the rule of sign in algebraical division, "this rule follows from the fact that the product of the divisor and quotient must be equal to the dividend."[8] The justification of the rule of sign in multiplication is the really important point.

It is in virtue of its necessary harmony with this highest generalisation of negative quantities, that the form of statement which algebra selects as that

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[8] Todhunter's *Algebra*, 5th ed., 1870, Art. 94, p. 41.

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into which it throws all the general results, from which the solution of particular cases may be deduced, as well as all the enunciations which lead up to them,—I mean the form of Equation,—is itself the highest instance of the generalisation of processes, or operations with numbers or quantities. The demonstration of equalities is the sum and substance of all exact measurement. In the particular object-matter of calculation, which is number or quantity, the statement of equality, of which the sign = is the expression, takes the place of the copula *is* in the affirmative judgments of logical thought generally. It says much more than the simple copula *is*, namely this, that the two numbers or quantities between which it stands, or which it equates, are in point of quantity convertible. From which it follows, that the equation is a logically convertible judgment, or two simple logical judgments, *A* is *B* and *B* is *A*, in one; this being rendered possible by the restriction of the object-matter of the equation to quantity or number only. The negation of equality, if any, between the quantities or numbers dealt with is then thrown, not as in simply negative logical judgments into the copula *is-not*, as in *A isn't B*, but into one or both of the terms of the equation, as in

$$\mathrm{a} + x = \mathrm{b},$$

where x stands for the difference, whatever it may be, between b and a; which equation may also be expressed as

$$x = \mathrm{b} - \mathrm{a},$$

or again as

$$\mathrm{a} - \mathrm{b} + x = 0.$$

Algebra may thus be called, by analogy, the Logic of pure number or quantity, the sign = being adopted as the copula of all its judgments or enunciations.

In coming down from Equations as general formulæ to their interpretation in particular cases, I take the following from the Examples of the "substitution of numbers for letters" given in the article *Algebra* in the Encyclopædia Britannica; partly because it shows the way in which the symbols for nothing, 0, called zero, and for infinity, ∞, are employed in algebra:

"If $a = \frac{1}{2}$, $b = \frac{1}{3}$, $c = \frac{1}{4}$, $x = 0$,

Find the value of

$$\frac{a^2 - b^2}{x} - \frac{b^2 - c^2}{x^2}$$

The first term is infinite, and the second is infinitely greater than the first, because $x^2 = x \times x$.

$\therefore$ the answer is $-\infty$."[9]

Zero or 0, and Infinity or ∞, are here used precisely as if they were real quantities. The logical justification of this, I imagine, is twofold,—(1) that in calculation we are always, by supposition, dealing with quantity or number, and never with anything that is not-quantity or not-number, and (2) that the place in which, or point at which, a quantity or number appears, in calculating operations, is always that which determines its value. Now zero, or 0, is the place or point midway between positive, or +, and negative, or −, quantities. As an algebraical quantity it is greater than any *minus* or negative quantity. Similarly

[9] Encyc. Brit. Ninth Edition, 1875. Vol I. p. 519.

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with infinite, or ∞, quantities. One of them can be greater or less than another, according to the places which they respectively hold in the calculation by which they are arrived at. The validity of this proceeding rests on the double character, pointed out above, as inherent in all number, (1) as an act of counting, (2) as an unit or group of units counted. *Zero*, as a quantity counted, means the absence of a numerical content from a particular place arrived at in calculation, that is, in a series of acts of counting, as *e.g.*, in subtracting (say) 9 from 9; *infinity*, as a quantity counted, either positively or negatively, means the presence of a numerical content greater than any assignable content, at a particular place arrived at in a similar manner, as *e.g.*, in multiplying 0 by 0 (x by x) in the above example.

Zero in number and null quantity in continua, both alike indicated by 0, must therefore be carefully distinguished from the logical negation or contradictory of number or quantity, as modes of perception generally. The real existence of numbers or quantities, in the sense of places or points in a series of acts of counting, and therefore their possible existence in the character of contents found in or at those places, is assured by, because inseparable from, the act of counting or calculation itself. Similarly the algebraical conception of infinity, or ∞, as capable of degrees beyond degrees, arrived at by calculation, must be carefully distinguished from that infinity which attaches to certain modes of quantity (though not to number) as modes of perception generally; I mean to Time and to Space, so far as they are essentials of perception.

Whether such algebraical values as these of infinity are capable of interpretation as applicable to the real world is another matter. That generalisation of arithmetical processes which we call Algebra carries with it, simply as a generalisation, the obligation of seeing whether, and in what way, its results are applicable to perceptual phenomena. Taken by themselves they are no guarantee of perceptual reality, any more than are the conceptions of hippogriffs or chimæras in ordinary logical thought. And this is true, even when the phenomena which they are employed to interpret are of such an abstract kind as the divisions of pure time-duration, or the geometrical configurations of pure or empty space. These must be considered as object-matters, in which the conceptions of purely algebraical calculation may or may not find exemplifications. In this respect the generalised conceptions and processes of algebra differ from those of arithmetic, of which they are the development. For, again to quote the article on *Algebra* in the Encyclopædia Britannica, "the operations of arithmetic are all capable of direct interpretation *per se*, whilst those of algebra are in many cases interpretable only by comparison with the assumptions on which they are based." (Vol. I., p. 511.)

"The Theory of Equations," we read in the same article, "may be termed algebra proper" (p. 515). But inasmuch as the dealing with unknown and variable quantities and relations of quantity (expressed by means of symbols) is the common and essential feature in the methods of all the higher branches of calculation, they may one and

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all be said in a very definite sense to be higher branches of algebra, and included under it. I take the general heads, under which these branches fall, from the article on *Analysis* in Chambers' Encyclopædia: "Mathematical Analysis, in the modern sense of the term, is the method of treating all quantities as unknown numbers, and representing them for this purpose by symbols, such as letters, the relations subsisting among them being thus stated and subjected to further investigation. It is therefore the same thing with Algebra, in the widest sense of that term, although the term algebra is more strictly limited to what relates to equations, and thus denotes only the first part of Analysis. The second part of it, or Analysis more strictly so called, is divided into the Analysis of Finite Quantities, and the Analysis of Infinite Quantities. To the former, also called the Theory of Functions, belong the subjects of Series, Logarithms, Curves, etc. The Analysis of Infinites comprehends the Differential Calculus, the Integral Calculus, and the Calculus of Variations." [10]

The Theory of Equations, the Theory of Functions, and the Analysis of Infinites, are thus the main heads under which all the branches, lower and higher, of Algebra in the large sense of the term may be distributed. I have quoted the above passage merely as giving a brief conspectus of the domains covered by the science of calculation as a whole. It would be entirely beside my purpose to attempt to enumerate, or in any way enter upon the consideration of the various divisions and sub-

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[10] Chambers' Encyclopædia. Edition of 1888. Vol. I., p. 248.

divisions contained in it. Nevertheless a word must be said, before quitting the subject, concerning the Analysis of Infinites or Infinitesimal Calculus, inasmuch as the conception of Limits, upon which it is founded, throws back light upon the original and essential nature of Number, of which in fact it is an immediate and necessary consequence.

The Infinitesimal Calculus deals with quantities which are *functions* one of another, that is to say, with quantities which are so related, that a change in either of them involves a corresponding change in the other. Its purpose is, by introducing first into one, then into another, of the variable quantities so related, which enter into the statement of any given problem, a series of changes, which, since they may be made indefinitely minute, and therefore indefinitely numerous, will carry with them corresponding changes in the other, or dependent, variables, sufficient to cover and, in thought, account for the whole content of any imaginable period of time or configuration of space, including all the possible relative changes in their parts. By this method of proceeding results are obtained, which, in subsequent application to the phenomena of Nature, are adequate to express, and even anticipate by calculation, any relations or changes of relation, which may exist or take place in the physical world of matter and force,—masses, volumes, motions, velocities, degrees of intensity, of energy, and so on,—and in short of anything whatever, so far as it can be brought under the head of quantity, that is to say, so far as the time and space relations involved in it are concerned.

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With changes in the quality of physical substances or forces, as for instance in chemical combinations and affinities, the Calculus has to do only so far as the occurrence of such qualitative changes can be shown to depend upon changes which are expressible in terms of time and space relations and therefore can be quantitatively ascertained. The Calculus may in fact be briefly described as an Organon for sweeping the whole field of the purely quantitative relations of phenomena, just as Aristotle's Logic is an Organon for sweeping the whole field of phenomena which are cases of the distinction between Identity and Difference, that is, of all phenomena whatsoever.

Now the fact of experience which is employed as the means and principle of method, in establishing and working this Organon of quantity, is no other than that which, as we have seen, is operative in originating number and calculation themselves. I mean the division of the time-continuum by an act of purposive attention, an ideal division which occupies no portion of that continuum into which it is introduced. The only difference is that, in the case of the Calculus, the division is introduced into continua of any kind, and with full consciousness of the two essential circumstances, (1) that the continuum to be divided is a pre-requisite of an ideal division of it, and (2) that the ideal division occupies no portion of that continuum, but always leaves a smaller continuum capable of still further ideal division, however often the process of division may be repeated. To be a continuum and to be capable of ideal division are one and the same thing.

The *Limits* instituted by the Infinitesimal Calculus (in its Differential branch), in dealing with variable functions for the purposes of its calculations, are divisions of this kind. We find them thus defined by a recent authority. "If there be a fixed magnitude to which a variable magnitude can be made as nearly equal as we please, and if it be impossible that the variable magnitude can ever be exactly equal to this fixed magnitude, the fixed magnitude is called the limit of the variable magnitude." [11]

To take an elementary and familiar instance. Imagine a circle, with a diameter drawn horizontally, meeting the circle towards the right hand, at a point which we will call O. Then imagine another straight line drawn through the point O, so as to cut off a portion or arc of the upper right hand quadrant of the circle, and call the point at which it again meets the circle B. Next imagine this line O B revolving on the point O as a pivot, in the plane of the circle, from left to right, so as to bring the point B gradually nearer and nearer to the point O; thereby gradually diminishing (1) the arc of the circle intercepted, (2) the length of the straight line or chord O B, and (3) the area enclosed between the arc and the chord, until these three quantities simultaneously vanish; which they will do at the instant when the point B attains exact coincidence with the point O.

Up to that instant, the line O B is a *secant* of the circle; at that instant it ceases to be a secant, and becomes a *tangent* of the circle; and if we suppose it to continue to revolve from left to right on the

[11] Chambers's Encyclopædia, Art: *Calculus*, Vol. II., p. 636, New Edition, 1888.

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point O as its pivot, it ceases to be a tangent and becomes again a *secant* of the circle, only that this time the portion of the circle or arc which it intercepts lies below the diameter, and belongs to the lower right-hand quadrant of the circle.

The position of the line O B, at the instant when it becomes, and for so long as it remains, a *tangent* of the circle, is the *limit* of the successive varying positions which it occupied as a *secant* of the circle. And though *as a secant* it may be supposed to be brought as near as we please to its position *as a tangent;* that is to say, though its distance from the position of tangent may be diminished by successive differentiations, until we are tired of finding expressions for its minuteness;—yet it can never coincide with that position of *tangent* without *ipso facto* ceasing to be a *secant;* or, expressed in other words, the angle which *as a secant* it forms with the diameter, at the point O, can never be exactly equal to the angle formed by a tangent at that point (which is a right angle) without the line ceasing at the same time to intercept any portion of the arc or of the circle, however minute that portion may be supposed to be.

The sole and sufficient ultimate reason for this is, that the successive positions which we suppose the revolving line O B to occupy are ideal divisions of spatial continua, namely, of the area contained within the circle, and the area or space outside the circle, and continuous with that within it, save for the ideal division introduced by the circle itself. For ideal divisions of a continuum are no solutions of its continuity, that is, they do not introduce breaks or intervals into it, which do not belong to

the continuum, as physical divisions of a material continuum would do. From which it follows that, in traversing a continuum, or supposing the motion of a point traversing it, (whether the continuum is one of time, or of length, or breadth, or volume of space), this motion also is continuous in respect of the continuum traversed; that is, it can skip, or leave untraversed, no portion, however small, into which it either has been or possibly might be ideally divided, that is, whether these ideal divisions have been expressly noted or not. With regard to the continuity of motion traversing a continuum, it makes no difference how many or how few ideal divisions are introduced into it, since no number of such divisions can exhaust its divisibility, but there must always remain a continuum capable of further ideal division. In short, continuous motion can traverse the whole of, and in that sense exhaust, a continuum; ideal division of it cannot.

It is entirely beyond my purpose to enter upon the ways in which the fundamental conception of Limits becomes the basis of the methods, first of the Differential Calculus, and then of the Integral, which is its converse, complement, and application. What concerns us here is the nature and validity of the *Lex Continui* itself, of which the conception of Limits is the direct and immediate consequence. With regard to this it must first be remarked, that the representation of a continuum, whether of time, of space, or of motion, is a representation of facts of sense-perception taken in their lowest and simplest instances, and therefore has the direct warrant of experience. Objections to its ultimate experiential validity must, on the other hand, be

drawn, not directly from the data of sense-perception, but from conceptions which thought frames of time, space, and motion, considered severally as abstract objects, that is, from the concepts of them, or from time, space, and motion as concepts. For it is only then that the questions can even be raised, whether Time may not in reality be a succession of discrete instants, Space a co-existence of discrete points, and Motion a succession of leaps from one co-existent point of space to another, each leap being performed in a discrete instant of time. Nothing but confusion has ever resulted, or can ever result, from this putting of concepts into the place of percepts, as the ultimate source and test of validity. The Eleatic puzzles about Motion are an instance.

The answer which is drawn from experience to the above questions is very simple and conclusive.

1st. If Time consists of a succession of discrete instants, of what does the interval between those instants consist? For plainly, unless there were intervals between them, the instants could not be discrete, and the idea of their succession must disappear together with that of their plurality. The answer to the first question therefore is, that these supposed intervals are Time, the supposed instants ideal divisions of it, and Time itself a continuous duration, capable, because continuous, of ideal division *in infinitum.* The ultimate nature of Time, as an inseparable element of consciousness, is not succession but duration.

2nd. If Space is a co-existence of discrete points, what is the interval or distance between any two of those points? It is plainly space. The

points are ideal divisions of it; and Space is a continuum capable, because it is continuous, of ideal division *in infinitum*. Its ultimate nature, as an inseparable element in certain states of consciousness, is not configuration but extension.

3rd. If Motion is a succession of leaps from one co-existent point of space to another, each leap being performed in a discrete instant of time, then,—whether time and space are taken as really continuous or not,—Motion could only take place outside time and space, namely, by quitting them at one point and returning to them at another. This is evident, if time is taken to consist of discrete instants, and space of discrete points. And hardly less evident, if either time or space is taken as continuous; for then, taking time as continuous, motion must quit time, if it is to be discrete in respect of time, and taking space as continuous, motion must quit space, if it is to be discrete in respect of space. Thus the conception of motion as discrete not only contradicts the usually accepted conception of it founded on experience, namely, that it is a traversing of a portion of space in a portion of time, but also fails to be in itself an intelligible conception, since we know of no medium or media into which motion can be conceived as jumping, when it is supposed to consist in jumping either out of space or out of time, and into them again. Consequently we have no alternative but to conceive motion as equally continuous with those portions of space and time which are necessary elements in its description; that is to say, as continuous in the sense that it leaves no portion of the

space untraversed, and no portion of the time unemployed.

Cavillings at the general fact or law of Continuity, like those which I have just attempted to criticise, seem to arise from endeavouring to frame conceptions of Number, Time, Space, and Motion, which may suit the purposes, or perhaps serve as the ultimate bases, of the sciences of Calculation, Geometry, and Physics, without having recourse to the subjective analysis of experience. These realities are then taken severally, each as the object of a separate and independent conception. But this method hinders perception of the fact, that, while continuity and divisibility involve and imply each other, nevertheless continuity and its ideal division are not *in pari materia*, in respect of their basis in experience. Continuity is the representation of an elementary fact given in all sense-perception. Its ideal divisions are introduced by acts of purposive attention on the part of the percipient. Ideal divisibility, but not any particular ideal division, is involved in every continuum presented or represented. The only indivisibles, therefore, in Number, Time, Space, and Motion, are divisions in, and therefore between, continua, which divisions are not continua themselves, as compared to what they divide. Hence it is that, in introducing ideal divisions into any finite continuum, there is always a continuous residuum interposed between the last division which we introduce and the boundary of the finite continuum into which we introduce it, a residuum which is always greater than 0, and always capable of further ideal division. The ideal divisions which we introduce take place *per saltum*;

but this supposes the given continuity of that into which they are introduced, prior to their introduction. The minute continua between these ideal divisions, which may be made as minute (and as numerous) as we please, are the so called infinitesimals, or "infinitely little" quantities, of the Calculus. We pass over them *per saltum* in thought, but they cannot be passed over *per saltum* by any motion which is thought of as real. Motion, to be real, must be continuous. It is a fallacy to attribute to Nature the divisions which we introduce into the phenomena of Nature, in order to calculate or to measure them.

Throwing a retrospective glance upon what has now been said, we see that the science of pure calculation has, for its first or immediate object-matter, pure or abstract Numbers and their relations *inter se*, treated as if they were realities, having properties, entering into relations, and subject to laws, of their own; notwithstanding that they are the creatures of acts of counting, which are the first steps in the science of calculation, and that their properties, relations, and laws, are discoverable only by continuing and developing those very acts of counting and calculation, by which they have originally been educed out of perception by thought. Numbers treated in this manner, namely, as separable from the acts which produce them, are the first or immediate object-matter of the science of pure calculation.

As creatures of thought, in counting and calculation, on the other hand,—which is a character

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equally essential to them,—all numbers are ideal as well as real; that is, in metaphysical terms, they are objective thoughts, even when they are taken as themselves objects thought of in reflective consciousness. But though all alike are both real and ideal in this sense of the terms, yet they are again subject to a somewhat similar distinction which must by no means be confused with it, I mean the distinction between real, or rational, and imaginary, or irrational, according as they are or are not strictly commensurable with unity, and therefore are or are not capable of exact expression by a finite number of figures. Such irrational numbers are also called surds, the square root of 2, or $\sqrt{2}$, for instance. Within this class of imaginary or irrational numbers we may again perhaps distinguish those which are simply impossible and unreal, because of a contradiction involved in the conventional terms used to describe them, such as is found in the idea of an even root of a negative quantity, $\sqrt{-1}$, for instance.

Thus in its whole range we see that pure calculation provides its own immediate object-matter, and is independent of any object-matter otherwise supplied. It cannot be said to be more applied to, than productive of, its own object-matter. It investigates in producing, and produces in investigating. Its laws and those of its object-matter, speaking broadly, are the same.

But besides this it is applicable to object-matter extraneous to itself, arising from a wholly independent source in sense-perception; applicable to it, therefore, in the strict sense of that term, which imports heterogeneity. And to this it is applicable,

from being involved in the methods, that is to say, in the sciences, by which the laws of that extraneous object-matter are investigated. This secondary object-matter of pure calculation falls under two main heads, one nearer to pure number in point of abstractedness than the other, but both of them purely quantitative in character, and both of them allied to it and to each other by the central or fontal conception of Equality, which is common to all alike. The first of these consists in the figurations of space, and the directions and velocities of motion, which are the object-matter of pure Geometry and Kinematic; the second in the volumes, masses, forces, and energies displayed by physical Matter, so far as these can be treated quantitatively, and made the object-matter of any exact physical science.

The foundation for this application of pure calculation to spatial and physical quantities is laid by taking some continuous part of any such quantity, expressing it by a number, and using that number as an unit of measurement; as for instance, in spatial length, if we take a foot as our unit, and call it 1, then 1 multiplied by 3 represents the length called a yard, and divided by 12 an inch. The circumference of a circle again is divided into 360 equal arcs called degrees, each of these into 60 equal minutes, and each of these again into 60 equal seconds, every equal arc subtending an equal angle at the centre of the circle. All these being expressed by numbers can be dealt with numerically, that is by processes of pure calculation, the results of which must be re-translated, at the end of the processes, into determinations of space, the

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same in kind as those for which the numbers were at the outset substituted. It is precisely as if calculation was a language with a meaning; only that calculation (unlike the sounds of language taken by themselves) has meanings of its own, namely, numerical meanings, over and above the spatial (or physical) meanings which *ex instituto* it is employed to express.

Starting from such simple beginnings as these, all imaginable configurations of space, directions, motions, velocities, and their changes, may be brought within the range of pure calculation. The whole of analytical geometry consists in the application of it to the extraneous object-matter of space figuration. And owing to the extreme generality of its symbols and methods, combined with the minuteness of what we may call its search-light, the Calculus, we may be confident, that no portion of space, time, or possible motion, need be left unrepresented in its results.

From this, however, it by no means follows that all the results, in the shape of algebraical or symbolical expressions, to which pure calculation comes, or which are deducible from its processes, in the course of such applications, must have correlates represented by them, in the object-matter to which the calculation is applied. Compared to the general conceptions and processes of pure calculation, the object-matter which we know as figurable and measurable space, time, and motion, is a given and particular object-matter. Its phenomena, though highly abstract, do not admit of generalisation in the same way as simple arithmetical number admits of it, by the device of treating

unknown numbers as if they were known, and non-existent or negative numbers as if they were existent for the purpose of calculation. Consequently the question can never be avoided, whether the symbolical expressions at which we arrive, or which are involved, in calculation can or can not be interpreted as indicating or representing any positively conceivable features or relations in the given object-matter; for this object-matter has a nature and laws of its own, wholly independent of those processes of pure calculation, which are employed indeed in discovering them, but are not, of themselves, either limited to that discovery, or in any way creative of the nature and laws which they are employed to discover. Acts of purposive attention to the time-stream of consciousness give rise to Number and to Calculation, but neither number nor calculation gives rise to the perception of spatial extension, or to that of motion which pre-supposes it. It is from acts of purposive attention to the perceptions of spatial extension and motion that Geometry arises; and by this object-matter it is, that its purpose and definition as a science are determined. However necessary pure calculation may be for the due exploration of spatial phenomena, it can never alter the nature which they derive from spatial extension, nor that of spatial extension itself as an immediate datum of experience.

These remarks apply still more obviously to that more concrete object-matter of pure calculation which consists of physical masses, forces, and energies These also, including their intensities, directions, and changes, are brought into the domain of calculation by the same means, namely, by taking

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units of measurement numerically expressed. Provided always, as before, that they are treated solely as existing and taking place in time and space, that is, as quantities, and in abstraction from their real conditions and consequences, other than those which can be expressed as quantities of the forces themselves. Qualitative changes, such as those which take place in consequence of chemical affinities between substances, though they may result from quantitative changes, such as changes in configuration, in the substances which are brought together, are thus, as qualitative, excluded even from this secondary object-matter of pure calculation; though they are also thereby *ipso facto* classed as belonging to a third and still more remote object-matter of it, I mean in virtue of their dependence upon purely quantitative physical changes, belonging to the second head, so far as the laws of those changes can be quantitatively ascertained.

Pure calculation may thus be considered as an *a priori* quantitative treatment of the phenomena of the whole physical world,—*a priori* of course not in the transcendental sense of the term, but in the sense of its being founded in the necessity we are under (owing to time and space being inseparable elements in the ultimate data of experience) of conceiving them as phenomena existing in and occupying time and space, and restricted to being a treatment of them in that character alone. It works out on the one hand the imaginable possibilities, on the other the unavoidable necessities, attaching to those phenomena. It may thus, within these limits, both suggest new hypotheses to the physicist, the chemist, or the biologist, and also test hypotheses

already suggested, by working out the quantitative consequences which they involve.

Yet pure calculation, though based on divisions of time alone (and not of space), is not the science of time, in a sense analogous to that in which pure geometry may be said to be the science of space, namely, as being the science of its configurations, or of figurable space, or of figured space and its boundaries, points, lines, and surfaces, together. Lengths of time are not the object of calculation in the same immediate sense as extensions and figures are the object of geometry, though calculation may of course be applied to determine them. Time-lengths are not the content of numbers, as space-extensions are the content of space-boundaries. Numbers arise originally from successive acts of dividing the time-continuum, but the equality of all single numerical units *inter se* does not arise from any perceived equality in the several intervals between those successive acts of division. The length of these intervals has no more to do with the numerical value of the units, than has the length of time psychologically necessary for performing each act of division in thought. No unit of time-measurement is thereby furnished. The circumstance, therefore, that time is the only continuum which is indispensably necessary for performing acts of counting, that is, of making units, neither constitutes those acts measures of time-lengths, nor elevates the measurement of abstract time into the sole or even the principal purpose of calculation. Geometry is the science of measuring spatial extension divided or divisible; Calculation is the science of division itself,

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whatever may be the continuum which it is applied to measure.

Acts of counting are the first condition of, or ingredient in, the establishment of units of measurement; and the establishment of an unit, or fixed standard always equal to itself, is in turn the first and indispensable step in measuring phenomena of any kind whatever. In this way calculation in its whole development is directly applicable to the divisions or boundaries of space, namely, by breaking them up into units of equal length, or portions measurable by one another. Hence figures in space can be expressed by numbers; units of length, breadth, and volume, being once taken. The measurement of time-lengths by means of constant and generally applicable units depends on the measurement of space-lengths as one of its conditions, and is therefore only indirectly possible.[12]

Hence Time, though (or rather because) it is the most fundamental condition of science generally, in its character as the one indispensable formal element of consciousness, escapes being the object-matter of any special science of its own. For in order to its being conceived as an object at all, it must be taken along with some determinations or differences belonging to its inseparable content, or co-element, of feeling, since time strictly pure is an

[12] See a paper by the late Edward Hawksley Rhodes, *The Scientific Conception of the Measurement of Time*, read before the Aristotelian Society, June 1, 1885, and published in Mind, Vol. X., p. 347, First Series. Perhaps I should also mention a paper by myself, *Time-measurement in its bearing on Philosophy*, published in the Proceedings of the Aristotelian Society, Vol. II., No. 2, Part 2, 1893.—I take this opportunity of gratefully acknowledging the assistance I have derived from conversations with my friend Mr. E. Hawksley Rhodes, during the latter years of his life, and also from correspondence with my friend (and *quondam* teacher in mathematic during his sojourn in England), M. Edouard Merlieux, on the subject of the present Section. Not that I mean in any way to cast upon them the responsibility for errors due to my own imperfect grasp of mathematical science, and still less for the course of my metaphysical speculations concerning it.

abstraction, incapable of being even brought into consciousness without some reference to that from which it is abstracted by thought. And furthermore, in order to its being treated as the object-matter of a special branch of science devoted to it alone, these determinations can only be drawn from that inseparable co-element of feeling which is exclusively its own, that is, from feelings which occupy time only, and not time and space together. But these feelings alone afford, as we have seen, no constant unit, applicable to the measurement of successive time-durations.

Time differs in this respect from space, the inseparable content or co-element of which, I mean the element of visual and tactual sensations, is rich in differences of direction and magnitude, which can be brought into juxtaposition and measured one against another. And these spatial measurements are in fact the ultimate means which we possess for the measurement of time-durations, though this only indirectly. Ideally, indeed, we can imagine time divided into durations exactly equal to one another, and make of this an ideal standard, to which actual indirect measurements may be conceived to approximate. And this is in fact the very thing done by Newton, when he says of "absolute time," that it "flows equably," for that is equivalent to conceiving it divided into units of equal duration. In this conception of "absolute time," the science of time may be said at once to begin and end. As a body of doctrine it does not exist. Practically, however, its place is taken by the science of the Divisions of Time, that is, by Calculation, or the science of Pure Number. Pure

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Calculation and Pure Geometry, founded respectively on the two formal elements in all consciousness, time-duration and space-extension, are the two sciences which stand at the fountain head of all positive and exact science.

From the foregoing account of the applicability of abstract or pure Number to the measurement of particular contents or parts of that concrete time-stream of consciousness, out of which, by attention and abstraction, it springs, we see not only the origin of the conception of Quantity in general, but also the origin of the two kinds or classes into which quantity is usually considered as divisible, namely, those of (1) continuous, (2) discrete quantity. Number is discrete quantity, in the sense of representing the result of ideally dividing continuous quantity into a plurality of parts, or smaller continua, though it must be remembered, that it is only by division that an originally undivided continuum becomes, or can be thought of as, a quantity at all. A number is the name for one or more of the parts arising from such divisions. Numbers being then considered as consisting of one or more unit numbers, and continuous quantities being reduced to measurement by dividing them into unit continua,—the actual measurement of continuous quantity may be considered as answering the question *How much*, and the actual measurement of discrete quantity as answering the question *How many?* And the application of the latter to the former, when it can be effected, always tells us *how many* units of continuous quantity are to be found in the continuum which is measured. Continuous and discrete quantity are therefore, in

strictness, not two separate classes of quantity, but two distinct though inseparable ways in which quantity may be regarded. Without continuity no quantity could possibly exist; without discreteness it could not be recognised as quantity. The very idea of quantity arises from the purposive introduction of an ideal division into a given representational continuum.

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§ 6. From these brief considerations on the mathematical sciences of Geometry, Kinematic, and Calculation, I propose now to return to the relation which the phenomena of abstract space, time, and number, bear, when so treated, to the objectified panorama of the real external world, as presented to us by the metaphysical analysis of experience. And in the first place, the remarks now made on the subject of number enable us to state briefly how we come to attribute infinity to space and eternity to time, as they appear in that objectified panorama, and that in both directions, (1) divisibility, (2) extensibility, *in infinitum.* In the nature and origin of Number we have something wherewith to contrast, and by contrasting render intelligible, the infinity of time and space in both directions. Number is to time, as an objectified continuum, what geometrical figure is to space, as an objectified continuum; both are limitations introduced by thought into pre-supposed perceptual contents, which without them would be abstract continua; the perception of actual differences in the content, in both cases, being the circumstance which thought repeats in representation, and erects into an ideal limitation of space and time as abstract percepts. A series of numbers, say from 1 to 100, or on the

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other side of zero from -1 to -100, corresponds to a closed geometrical figure, say a cube or a sphere. The process of counting, that is, naming by figures or symbols, any limited number of units in time alone, with abstraction from space, is what the process of imagining a closed solid geometrical figure is in space and time together.

Now both these processes are processes of thought applied to perception, and both are conditioned as processes by the perceptions of time or of space, which are their pre-suppositions, and of which they are modifications. In number or in time, no number expressing a length of time can be named so great that you cannot add 1 to it,—an ability which necessarily involves the existence of time beyond it; nor any fraction so small that you cannot decrease it by increasing its denominator, that is, suppose a shorter time within it. In space there is no closed figure so large that you can suppose there is no space beyond it, nor any so small that you cannot in thought interpose one still smaller between it and a mathematical point. Both processes may be carried on in both directions indefinitely, or *in indefinitum;* but they cannot be conceived as carried to completion, without contravening the conditions by which as processes they are constituted. In the case of the closed figure of space, to conceive the process of enlargement completed, by being carried to infinity, would be to conceive the figure annihilated as a figure. In a circle, for instance, the circumference would become in thought a straight line. In the case of numbering portions of time as continua, to conceive the process completed by being carried to infinity would be to destroy the

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possibility of the process itself, by exhausting the continuum, time, which is the object in and upon which the act of numbering is supposed to operate. The very meaning of their *infinity* is, that no process, either of adding portion to portion, or of successively dividing any portion of them into smaller and smaller portions, can ever exhaust their capacity for increase, or their capacity of being divided.[1]

Time and space, as those inseparable elements in concrete perceptions which are the source of their continuity, are therefore antecedent conditions of number and of geometrical figure respectively; these being definite limitations introduced, by means of thought attending to differences in the sense-element, into the pure and unlimited continuity of the abstract elements of time and space. Wherever you perceive a limit, either in time or in space, you also always perceive time or space on both sides of it, and not on one only. Their limits are differences or distinctions in their content, which are always found within, never beyond, their content in its entirety. Consequently, whenever you think of a limit ideally, you also think of a time or a space, as yet unlimited by thought,—beyond it if your thought is advancing in the direction of increase, within it if in the direction of decrease. All thought, it has been well said, is limitation; but it does not follow

[1] Among all the services which M. Renouvier has rendered to philosophy, there is perhaps none greater than his exposure of the fallacy of what he calls "*l'infini actuel*," or the thought that infinity can be actually realised, that is, represented as possibly finite. See his *Traité de Logique Générale &c.*, 2nd Edition 1875, Vol. I., pp. 44—67. Also his *Principes de la Nature*, 2nd Edit., 1892, Vol. I., pp. 80—84. Also his *Philosophie de la Règle et du Compas*, in *L'Année Philosophique* 1891, pp. 27—28. The last named work especially should be familiar to all students of the philosophy of geometry, notwithstanding that Kant's distinction between analytic and synthetic judgments is made one of the corner stones of the argument.

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that it can include either time or space as a whole within its limiting boundary. This is in fact prevented by the relation in which thought stands to perception, perception being one of its essential constituents, and time and space being, each in its kind, inseparable elements of perception.

From these facts it results, that, when we come to conceive time and space as abstract percepts, we must conceive them as infinite, because we perceive them only as inseparable elements in perceptions, and therein as existing beyond as well as within any limit or difference which we perceive in them, or any boundary which we can impose upon them by thought. As inseparable elements in perception, their essential character is *continuity;* and this perceptual character is the basis of their infinity, when they are taken as abstract percepts. Thus the perception of their transcending any limitation, whenever we bring it to the test either of presentation or of representation, is the fact which, when we consciously attend to it, becomes the conception of their infinity; the infinity of time, in the direction of extensibility, being called by the particular name of *eternity.* Those things and those only which have no possible or conceivable final limits are conceived as infinite. Nothing to which we can conceive a final limit can be conceived as necessarily, or in its nature, infinite, though it may be conceived as indefinite, that is, as becoming either indefinitely great or indefinitely small. Time and Space it is beyond our power to conceive as having such a final limit. We conceive them as both unlimited and unfigured continuity. It is a simple logical blunder to suppose, that time

or space, when conceived as infinite, are conceived as *completed* totalities, (which would be to conceive them *eo ipso* as finite), on the ground that all conception is limitation. The perceptual fact that time and space escape or transcend limitation by conception, not the perception of time and space as totalities, is indeed itself a limitation; not however a limitation which conception imposes upon time and space, but one which they, as perceptually given data, impose upon our power of conception. The fact that they escape limitation by conception is the very fact by which our conception of them as infinite is itself constituted, or by which it becomes a definite conception.

With closed figure and number, on the other hand, the case is different. They are constituted by limitation, the limitation of conscious attention and thought. Their nature and being is to have a limit or a boundary. Consequently, though we may conceive them as magnitudes capable of indefinite expansion or indefinite contraction, we cannot conceive them as unlimited in magnitude, in either direction, without conceiving them abolished altogether as closed figures, or as continua expressed by numbers. There is no such thing as an infinitely great or infinitely small closed figure; there is no such thing as an infinitely great or infinitely small continuum of time expressed by number. Changes in their magnitude are capable only of an indefinite progression.

Time and Space, as the formal element in perception, being continua occupied by feeling, the material element, and distinguished into portions by differences in feeling, are the ultimate founda-

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tion of every conception of Quantity or Magnitude. Similarly the material element, with its countless differences, is the ultimate foundation of every conception of Quality. Quantity and Quality are perceptually contrasted, but are not logical opposites. This follows from their nature as conceptions, framed by thought, of what, as data, are ultimate and inseparable elements in all empirical percepts. The logical opposites of quantity and quality in general are *not-quantity* and *not-quality*, either of which, if affirmed of anything concrete, would be equivalent to affirming its not-being, that is denying its existence; since both alike are conceptions of elements which are essential, as well as inseparable, in the composition of perceptual realities.

Quantity again, when taken as we are now taking it, in connection with the analysis of consciousness, and not only in respect of its place in mathematical theory, is exhaustively divisible into the logical opposites, finite and infinite quantity. Every quantity which is arrived at or described by numerical or geometrical limitation is a finite quantity; every quantity which continues beyond every such limitation, and in virtue of that continuation, is an infinite quantity. But this *beyond* is of two kinds. If the successive limitations are in the direction of division or decrease, κατὰ διαίρεσιν, the infinity of the quantity which escapes them is expressed by saying, that it is infinitely divisible, or divisible *in infinitum*, without ceasing to exist as quantity. If the limitations are in the direction of addition or increase, κατὰ πρόσθεσιν, then the quantity which escapes them is called infinite simply, or in the case of

time, eternal. We may, perhaps, tabulate quantity taken in this sense as follows:

$$\text{Quantity in general} \begin{cases} \text{Finite.} \\ \text{Infinite} \begin{cases} \text{Infinite in order of increase.} \\ \text{Infinite in order of decrease.} \end{cases} \end{cases}$$

No piling up of finite quantities, no process *in indefinitum*, can ever result in infinite quantity, for infinite quantity is essentially continuation beyond any conceivable limit whatever. Such is our conception of time and space, owing to their perceptual origin, as the formal element in perception, in which they appear as the durational and extensional co-elements with feelings of any and every kind. Such is our conception of them when they make part of the one real world, the objective panorama of real existence, necessarily imparting to it their own infinity, and as it were incorporating the positively knowable world with the infinite universe of which it is a portion. To conceive time, space, and the universe, as infinite, is to conceive the fact, that, as percepts, they transcend conception.[2]

I pass now to another branch of the subject. We have seen in the foregoing Section, that there is no science of absolute time taken alone, but that any measurement of time which is generally applicable depends upon some previous measurement of

[2] For a fuller discussion of this subject I would refer to my *Philosophy of Reflection*, Chapter VIII. (Vol. II., pp. 67—121), and also to my Aristotelian Address for Nov. 1893, *The Conception of Infinity*, published in the Proceedings of the Aristotelian Society, Vol. II., No. 3, 1894, though there are some statements in the latter, to which I should now perhaps not be inclined to adhere.

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objects or motions in time and space together. In a certain sense, therefore, the measurement of space is the antecedent condition of the measurement of time, and it is to this that I now have to advert.

The ordinary geometrical conception of real but abstract space is a conception of it as a boundless Vacuity, or extension in all directions, an abstraction which is positively apprehended only by retaining in thought some determination drawn from its material co-element in perception, wherewith to contrast the total emptiness of the formal element alone. The minimum determination, or *sine qua non* of apprehending abstract space, is the thought of a mathematical point within it, as a centre of diverging lines, or directions, in which motion may be conceived to take place, without limitation or deflection arising from the vacuity into which it is conceived as proceeding.

Our original complex perception of the concrete world of space involved the perception of it as surrounding a single constant centre; but this centre was occupied by a concrete object, the body of the percipient, as was shown by the analysis given in Book I. But when we abstract the formal element called space from this concrete world, and objectify it by itself as an abstract object, we not only abstract from any particular concrete object as its centre, but we find that the mathematical point, which we then retain in thought as the minimum condition of conceiving it at all, has no particular position in it; seeing that no other point or points are retained in thought, by relation to which a particular position could be assigned to it. We have in fact a perfectly free hand in introducing

determinations and figurations into our representation of real but abstract space, subject only to the condition, that they shall not contradict that conception of it which is drawn from experience, namely, as abstract and boundless Vacuity, extending in all directions from any point which we may take as a centre. It follows, that all the directions, determinations, or figurations, which we may introduce into it, will be ideal divisions of one infinite and continuous space, just as, in the foregoing Section, we saw that all production of Numbers consisted in acts of dividing the time-continuum.

Now in order to establish a Geometry, or scientific system, of all possible determinations or figurations of space, which shall be adequate to this conception of it as boundless Vacuity, and at the same time be applicable to the measurement of the concrete physical phenomena of the world of space, the first and most essential step is to reduce to some order that indefinitely great number of directions, spoken of as "all possible directions," from a single point of space taken as a centre. This is effected by the system of three rectangular axes of co-ordinates, introduced by Descartes, and laid by him at the foundation of his application of algebra to geometry, known as algebraical or analytical geometry.

To understand what is meant by this, imagine three straight lines, each capable of being prolonged in either direction to infinity, crossing each other at right angles, at any single point of space. One of these lines represents the direction or directions *up* and *down* from the point of intersection, another the

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directions *right* and *left*, and the third the directions *forwards* and *backwards*, from the same point. It is evident, that we may replace these three straight lines by three planes, intersecting each other at right angles, and meeting at the same single point; one of which planes will lie midway between, and at right angles to, the directions *up* and *down* from that point, another midway between, and at right angles to, the directions *right* and *left* of it, and the third midway between, and at right angles to, the directions *forwards* and *backwards* from it. It is also evident, that every other point of space but this central point must lie somewhere or other either on these lines or planes themselves, or else in the eight regions into which they divide the whole space, otherwise undivided.[3] It follows, that the three Cartesian axes of co-ordinates afford a means of ascertaining the position of any point in space, by measuring its distance in a straight line from each of the three straight lines called axes, or from the planes by which they may be replaced. And these three axes or directions are known as the three dimensions of Space, because those directions and that number of them, namely *three*, are at once necessary and sufficient to map out, and afford a

[3] These eight regions are eight pyramids, each formed of three sides and a base (the base being at infinity), and having a common apex. To realise this in imagination, take, say, an orange, and divide it into two halves horizontally, the horizontal division standing for the first of the three planes spoken of above. Next divide it into two halves vertically, by a cut at right angles to the directions *right* and *left*; and then again into two halves, by a cut at right angles to the directions *forwards* and *backwards*. Taking in the next place the upper half of the orange formed by the first or horizontal cut, it plainly now consists of four solid quarters or quadrants, divided one from another by the two vertical cuts already spoken of, and from the lower half of the orange by the first or horizontal cut. The lower half also consists of four exactly similar quarters; eight quarters in all; whereby the whole orange is accounted for. Finally imagine the surface, or superficial boundary, of the orange removed, whereby its eight quarters are laid open in the direction of their bases, and away from their common apex at the centre of the orange, and you have the image of infinite or boundless space exhaustively mapped by its three dimensions.

means of measuring figurations within, the whole of that infinite Vacuity which bears the name of Space. All other directions, or dimensions as a means of measurement, as well as all figurations or determinations, must lie somewhere within the regions of space marked out by these three. They divide it exhaustively because they share its infinity.

It is less accurate language to speak of length, breadth, and depth, as the three dimensions of space, or of figures within space. A dimension means a direction by reference to which measurements may be effected. Breadth involves two such directions, represented in their simplest form for the purposes of measurement by two straight lines in the same plane at right angles to each other. Depth involves a third direction, represented for the same reason by a straight line at right angles to both the others. Breadth and depth, therefore, are not dimensions of space, but properties of its figuration determined by dimensions ; breadth by two, depth by three, beginning with the first, that is, with the direction in which length alone is ultimately measured, and which is represented by a straight line, because a straight line alone is identical with the distance between any two points.[4]

Still less can lines, surfaces, and solid figures, be called dimensions of space. Lines are a general

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[4] As to the distance between any two points being always unique, representable by a straight line only, and the consequent necessity, to which all geometry is subject, of taking the straight line as one of its ultimate bases or axioms, see an admirable paper, "The *a priori* in Geometry," by the Hon. Bertrand Russell, read before the Aristotelian Society, March 30th, 1896, and printed in its Proceedings, Vol. III., No. 2, page 97.—I would also call attention to Mr. Russell's *Essay on the Foundations of Geometry*, Cambridge, 1897, a work which came into my hands only when the present Section was already in the Press.

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class, containing the two kinds, straight lines and curved lines under it. Surfaces are a general class, containing plane and curved surfaces. Solid figures are a general class, containing innumerable sub-classes, according to the nature of the surfaces which are their boundaries. It is true that a curved line, equally with a straight one, when taken by itself, has no breadth, and in this sense may be considered as having only one dimension. But this only means, that it is to be regarded as a division or dividing of space, a boundary between surfaces; not that it can serve as an ultimate means of measurement, that is, be itself a dimension of space, or be used as one, until its own direction, that is, its curvature, has been ascertained. A similar remark holds true of curved surfaces, and again of solids. It is only straight lines which can serve as the ultimate dimensions of space, or of figures within space, because they alone are ultimate as determinations of distance between any one point and another.

By thus taking the three Cartesian axes of co-ordinates as its three dimensions, we come back to that very conception of Space which we have seen is justified by the metaphysical analysis of the experiences by which it was originally acquired, and which, when objectified by itself as an abstract object, as it is in pure geometry, is identifiable with Newton's conception of "true, mathematical, and absolute space," (*homaloid* space as it is now called), given in the Scholium already quoted. Newton's words are, "*Spatium absolutum, natura sua sine relatione ad externum quodvis, semper manet similare*" [homaloid] "*et immobile.*" Thus Newton's concep-

tion, the metaphysical conception, the ordinary common-sense conception, and I venture to think the strictly geometrical conception of space also, coincide in the essential circumstances of representing it as (1) continuous extension, (2) of three and only three dimensions, (3) infinite, and therefore (4) one space only, and not many.

But this conception of space is apparently and *prima facie* contradicted by certain new developments, partly due to new conceptions in the domain of Geometry proper, and partly to the application of algebraical methods to it, which in recent times have been widely recognised as established truths. I speak first of what is known as non-Euclidean geometry, and secondly of what is closely connected with it, namely, hyper-geometrical geometry, or the geometry of four or more dimensions, or briefly of n-dimensional space. A few words must be said on both these topics, with the view of showing, (1) that the non-Euclidean geometries are inadequate as geometries of infinite space, but at the same time are not contradictory of that conception, and (2) that the conception of n-dimensional space is self-contradictory and unthinkable; a result which would preclude us even from supposing that such a space or spaces might possibly exist, though inaccessible to beings endowed only with human powers of perception. Logical contradiction is a reason for denying real existence, widely different from any reason for denying it which arises only from the limitation of human powers. Space of n dimensions, as I shall attempt to show, is as logically unthinkable as the proposition in arithmetic, that $2 + 2$ make 5, or that in geometry a square

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and a circle can be identical. If n-dimensional space involves a logical contradiction, the idea of its existing in other worlds than ours cannot even be entertained.

We saw in the foregoing Section, that in the science of calculation the determination of quantities was effected by means of symbols, which had a meaning and use in calculation, quite apart from the consideration whether the quantities symbolised were real, or imaginary, or even contradictory. We saw that the symbols for nothing, 0, and for infinity, ∞, were capable of various significations, according to the place they held in the particular calculation in which they occurred; that ∞ was capable of degrees, one double (say) of another; and that 0 did not necessarily imply the vanishing of quantity altogether. In short we saw, that the conception of quantity in general was involved in the proceeding, the act of purposive attention, upon which the whole science of calculation or determination of particular quantities depended.

Now precisely similar to the position held by the conception of quantity in general to the science of calculation is the position held by the conception of "absolute space," or figurable Vacuity, to the science of geometry, as the science of the determinations or figurations of space. It is on the basis of that conception that all geometry proceeds, or in other words, "absolute space" is pre-supposed as the existent into which divisions, directions, magnitudes, modes of measurement, configurations, and relations and systems of configurations, may be ideally introduced by the geometer, subject only to the conditions, (1) that the axioms from which he

starts shall be statements of self-evident perceptual facts, and (2) that the systems at which he arrives shall be logically consistent within themselves, and with the axioms with which he begins. The apparent non-fulfilment of the first of these conditions by Euclid's eleventh axiom (I mean that which lays it down, that two straight lines in the same plane, when prolonged, must sooner or later meet, if another straight line which crosses them makes the interior angles, on the same side of the crossing line, together less than two right angles) was in fact the circumstance in which those investigations originated, which finally, in the hands of Lobatschewsky, Gauss, Beltrami, Riemann, Von Helmholtz, and others, resulted in establishing the possibility of self-consistent but non-Euclidean geometries. Euclid's geometry, it was contended, was not, as previously supposed, the same thing as the geometry of "absolute space," but only one out of three systems of geometry, each of which, on its own assumptions, but on those only, was a perfectly self-consistent system of geometrical truths.

The enquiry seems to have commenced by Lobatschewsky's publication, in the years from 1829 to 1840, of results obtained on the assumption, that the interior angles of any triangle, taken together, were not always equal to, but somewhat less than, three right angles. These results were welcomed by Gauss, as harmonising with a conception which he had previously entertained; namely, the conception of surfaces which had the same constant measure of curvature; that is, were such that they could be imagined to be bent or rolled in

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different ways without distortion of parts relatively to one another; or, again, were such that all figures drawn on them were freely movable in all directions, and to all parts of them, without any change in their lines or angles as measured on the surfaces themselves. Now these surfaces, that is, all surfaces having a constant measure of curvature, were exhaustively divisible into three classes, namely, (1) those where it was constant but positive, or representable, as an algebraical product, by the sign +, as in the surfaces of spheres of equal radius, (2) where it was constant but negative, or representable as an algebraical product by the sign −, as in surfaces roughly figurable by the upper surface of a saddle, called pseudo-spherical surfaces, and (3) where it was constant but null, or 0, as in perfectly plane surfaces.[6] Supposing this distinction between the three classes of surfaces having a constant measure of curvature to be established, it would follow, that Euclid's geometry is valid for those spaces only, the laws of which are deducible from the properties of plane surfaces, and not for spaces the laws of which are deducible only from the properties of surfaces having either a constant positive, or a constant negative, measure of curvature. For only in the former would his axiom concerning parallels hold good.

Three different kinds of surfaces having been thus in the first place distinguished and defined, we are next called upon to conceive three kinds of three-dimensional space, the nature of which is deter-

[6] See Von Helmholtz's paper, *The Origin and Meaning of Geometrical Axioms*, in MIND, Vol. I. (First Series), pp. 305, 306. The paper may also be found in its original German, in Von Helmholtz's *Vorträge und Reden*, Vol. II., edition of 1884.

mined by the three kinds of curvature proper to the surfaces which are their boundaries. We have thus spherical space of three dimensions, or spheres; pseudo-spherical space of three dimensions, say for instance, saddles; and homaloid or Euclidean space of three dimensions, as a portion of which any solid figure may be treated. Evidently the difference between the three kinds of solid spaces, seeing that so-called "absolute space" is indifferent to any configuration which may be ideally introduced into it, is a difference which depends solely on the different methods by which different configurations of space may be ideally constructed. Spheres and saddles are plainly not incapacitated for being treated as portions of homaloid space, by being also treated as solid figures generated by surfaces of constant positive or of constant negative curvature.

Spheres, when treated as so generated, must, I suppose, (for I speak only as an outsider, not as an adept), be conceived as consisting of an aggregate of an indefinitely great number of concentric spheres, so that the laws of spherical surfaces would hold good throughout the whole solid sphere, of which a spherical surface is the outer boundary, and there would thus be no parallel straight lines, in Euclid's sense of the term, throughout the entire figure. What would be a solid cube in Euclid's geometry would, I suppose, if made subject to the laws of spherical space, become a solid six-sided figure, having that side of it which was turned towards the centre of the sphere smaller in area than the opposite side which was turned towards the circumference, and both

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these opposite sides would become curved surfaces. But all such figures would still be finite portions of "absolute space."

So also would be those solid figures which should be conceived as generated by pseudo-spherical surfaces, such as saddles. True, the edges of an enormously magnified immaterial saddle may be conceived as stretching to infinity, but still its contour would prevent its ever being adequate to fill "absolute space," which is infinite in all directions. The conception of a curved solid or three-dimensional space, as such, that is, apart from its contour, — except where its degree or measure of curvature is specified as null (which in fact takes back the conception of its being curved), —is to my apprehension repugnant to the idea of "absolute" or infinite space, which has no outer boundaries. How can continuous Vacuity be curved? Curvature is to me intelligible only as a determination or figuration within it, or in other words, a figuration having space of null curvature beyond it.

If this were admitted, then the new or non-Euclidean geometries would, so far as I can judge, be perfectly compatible with the metaphysical and Newtonian conception of infinite, and so-called absolute space. For then the three kinds of figuration of space, spherical, pseudospherical, and homaloid, would be conceived as standing each on its own assumptions and principles of measurement, that is, would be conceived as creations of three specifically different geometries, or methods of ideally dividing space, and of constructing ideal figures within it. And the old or Euclidean

geometry may no doubt be regarded, from this point of view, as standing on an equal footing with the two others, namely, as developing an ideal configuration of space on its own assumption and supposed basis, the plane surface.

But this view of the new and old geometries necessarily opens the further question, which of these, and whether any of them, is adequate to deal with the phenomena of abstract Space as a whole; or in other words, whether the particular figured space constructed by any of them is identifiable with that abstract Space, which we know as the space of ordinary thought, and the conception of which is justified by metaphysical analysis. The answer to this question must be, that only one of those constructed spaces, namely, that which we are now regarding as the creation of Euclidean geometry, including as its distinctive characteristic that postulate or axiom concerning the meeting of certain straight lines, which was mentioned at the outset, coincides with and is adequate to account for, the whole of that infinite and absolute space. And this property it owes to the fact, that the assumption on which it stands, namely, that of null curvature, as in the plane, which makes it homaloid in the solid developed from the plane, identifies it in point of kind with absolute and infinite space, which is also homaloid, or in Newton's words "*semper similare.*"

Its adequacy may be shown as follows. Allowing, as the new geometry requires us to do, that Euclid's geometry may be considered as if it were founded on the properties of plane surfaces

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only, the dimensions of Euclid's space, in the sense of means or modes of measuring it, may be derived from features found in that space itself, namely, (1) a straight line, (2) the plane surface swept out by supposing that line to be moved in a direction at right angles to its own, and (3) the solid space swept out by supposing that surface to be moved in a direction at right angles to itself. Now if we suppose the originating straight line to be infinitely prolonged both forwards and backwards, (which is a postulate of Euclid's), then the whole solid space finally resulting would become infinite also, that is, would cease to be a closed figure, and would become identical with infinite space.

For it must be remembered, that Euclid does not himself take the plane surface as the basis of his geometry, but the straight line; and the straight line it is, which gives him his definition of the plane surface, of right angles, of the circle, and also, by means of the plane, of parallel straight lines, in which use is made of the postulate "that a terminated straight line may be produced to any length in a straight line," that is, of the conception of infinity. The idea, that the direction of a straight line is not altered by producing it, that is, by any change in its length, is at the very heart and centre of Euclid's geometry. Combine with this the idea, almost equally fundamental, that the measure of a right angle is everywhere the same, or in Euclid's language, that "all right angles are equal to one another," and you have a geometry in which not only the disputed axiom or postulate, which states what straight lines are parallel, holds true, but which, in that as well as in its other essential

characteristics, holds true of infinite or so-called "absolute" space.

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From these considerations it seems plainly to follow, that Euclid's, or at least an Euclidean, geometry must be re-instated in the position which it anciently held, as the geometry of absolute and infinite space, before the introduction of the new geometries founded on the conception of surface-curvature; the authors of which would seem to have lost sight of the simple fact, that infinity is involved in every, even the simplest, determination of spatial extension. Euclid's glance was far more searching, far more comprehensive. Indeed from this point of view it may be said, that the distinction between the Euclidean and non-Euclidean geometries has resulted in showing, that Euclid's much debated axiom or postulate was the form in which he clothed his perception (a perception not otherwise reduced to explicit statement), that Space, as distinguished from any figuration of it, was at once homaloid and infinite;—or in other words, was a given reality, as distinguished from a creation of the geometer's thought. The universal validity of Euclid's geometry depends ultimately upon this, that the straight line which is its basis, and which he defines by the specific difference *unity of direction*, in saying that it is the line which lies *evenly* between its terminal points, requires Vacuity as its sole but necessary pre-supposition. A single direction from any single point in abstract Vacuity is a straight line. No surfaces of any kind are here pre-supposed, upon which lines are thought of as lying, or by which their directions are restricted.

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But there is another question still to be asked, which is this. Does not the breaking up of geometry into three geometries, and consequently of space into spaces of three kinds, *ipso facto* dismiss and replace the old conception of a single "absolute" and infinite space? Or in other words, Is there in positive experience any such thing as an absolute and infinite space, for which any system of geometry can be required to account?

Now these questions, since they concern the nature and origin of our conception of space, belong to that border land of geometry and metaphysic, which appertains to the metaphysician as necessarily and legitimately as to the geometrician. Looking back, then, to the analysis offered in the present work of visual and tactual perceptions, which are those in which our conception of space originates, we find that they consist of two inseparable elements co-essential to those concrete or empirical perceptions, one of which elements is spatial and continuous, the other a sense-element consisting of various qualities or kinds of sensation; and that differences of quality belonging to the latter element are that which alone introduces, or attention to which alone enables thought on our part to introduce, differences of length and figure into the otherwise continuous spatial element, and consequently into the concrete stream of spatial perceptions.—It was farther shown that, in building up from these perceptions our complex perception of an external and material world, we do so only by perceiving ourselves as its constant central object; and consequently that, if we mean by *space* the space in which that external and material world of

positive experience exists, we arrive at that meaning only by abstracting and objectifying the spatial element in that world, in contradistinction from physical matter.

Space, therefore, supposing it to belong to the perceptual world of ordinary experience, must perforce mean for us that continuous non-material medium, which extends without imaginable or conceivable limits in all directions around the observer as a centre, and is inconceivable by him apart from the six directions, or three dimensions, which are given in and by that relation of it to himself. It is not as if Space was projected whole, from the recesses of a Kant's Transcendental Ego, or even was something somehow given *uno ictu* as a single object constituted by these three, or any other directions or dimensions, as its essential and intrinsic properties. No. Space is no more given with these dimensions, than abstract divisions of it, points without parts or magnitude, lines (straight or curved) without breadth, and surfaces (plane or curved) without depth, are given as original conceptions, from which by thought it may be constructed. Its three Cartesian dimensions (so to call them) are modes of distinguishing and measuring it, introduced into it by our thought, but introduced necessarily, on the ground of perceptual differences experienced by us during the building up of our complex perception of the material world, which is its concrete content.

But these three dimensions being adequate to bring every part of space, or of its content, into relation with our experience of it as a whole, or in other words, to determine the position of any real

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point in it whatever, and the relative position of any number of such points to one another, relatively to that system of axes, it follows, that space cannot have more dimensions than these three, of equal necessity with them, or incapable of being reduced to them, seeing that every other real direction or dimension taken in space must fall somewhere within the spaces which these three demarcate; and since a less number than three would be inadequate for the same purpose, it cannot possibly have less.[6] Our perception of space and our perception of its so-called necessary and sufficient dimensions have grown up in knowledge along with each other, and are inseparable alike from each other, and from our experience of the concrete spatial world.

Now this Space of experience, with its three and only three necessary dimensions, cannot be dismissed or expunged from experience. And if it is not the object-matter of geometry, what is it? Or of what science is it the object? The conclusion is therefore unavoidable, that certain conditions are imposed by perceptual experience upon all geometrical theory or speculation; namely, because it is space as perceived to exist in the external world of human observers, which is the positively known object-matter of geometrical science,—space which, so to speak, is pre-geometrically known. The space of experience is not the creation of the geometer. Not even geometers' spaces are that. It is impossible to construct space in

[6] I use the term *real* in this sentence to distinguish points and directions positively construable to thought from such as have a fictitious existence only, as corresponding, say, to imaginary roots of equations, or to some algebraical expression otherwise objectless.

any sense out of points, lines, or surfaces alone, for the simple reason that no point, line, or surface, is given in experience, or can be represented in thought, except in conjunction with spatial extension, and as a division or determination of it. Spatial extension is pre-supposed as the continuum which they distinguish into parts. The demand made upon all particular systems of geometry, that is, of space figuration, that they shall be adequate to account for this pre-geometrically known space, is therefore legitimate, and cannot be eluded. The pre-geometrical conception of space is the *explicandum* of geometry.

There is thus a wide difference between the Space of experience (though it is only *one*) and any single space which is constructed only by the geometer. The uniqueness of the space of experience is an immediate consequence of its infinity. That of a single space constructed only by the geometer is an immediate consequence of its limitation. A space constructed only by the geometer means, not a space simply, but some determination, or some figuration, of the space of experience, and contained within it. The geometer can construct spaces, in the sense in which lines whether straight or curved, surfaces whether plane or curved, and closed or partially-closed solids, are spaces; but Space in the sense of the all-embracing Vacuity, which the three Cartesian dimensions are employed to describe,—this he must pre-suppose, as the condition of his constructions. And this Space, being a pure continuum, and as such independent of any particular determination, cannot itself be conceived as *curved*.

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The construction of non-Euclidean geometries, based on the conception of surfaces as independent spaces, bears a striking analogy to Hegel's logical speculation, in which he bases his theory of Logic immediately on the conception of Judgments. The one disregards the conditions imposed by our pre-geometrical experience of space, the other those imposed by our pre-logical experience of perceptions, which are pre-supposed by judgments. Both alike seem to be governed by the imagination, that pure thought is creative of the content with which it deals, in dealing, the one with spatial phenomena, the other with all phenomena whatever; as if those phenomena were not percepts subject to perceptual laws, as well as being subject, and in order to their being subject, to laws of thought.—I conclude, therefore, that it is neither in the power, nor within the logical competence, of any geometry, to override the nature of space as given in perception, or alter the laws to which it is subject as the formal element of that perception.

So far we have been chiefly occupied with space relations as they appear in geometry proper. But further developments await us, when we proceed to bring the algebraical mode of dealing with them into prominence, as in analytic geometry; and here it is that we come upon the second of the two questions mentioned above, namely, that of n-dimensional space. Analytic geometry (so called) effects the measurement of space relations by dealing with them, not as perceptual configurations, but solely as represented by quantities capable of

ascertainment by algebraical calculation. The numbers and symbols used are taken as expressing possible relations of perceptual configurations of space, or other perceptual phenomena; but whether the results obtained by the calculation correspond to any real or actually imaginable phenomena, or to configurations of space which are interpretable in geometry proper, is left for after consideration.

This analytical method was applied by Riemann to the three kinds of space which we have just been considering. The path which he followed was, we are told, to "start with that view of space, according to which the position of a point may be determined by measurements in relation to any given figure (system of co-ordinates), taken as fixed, and then inquire what are the special characteristics of our space as manifested in the measurements that have to be made, and how it differs from other extended quantities of like variety."[7]

The expression n-dimensional space, or space of n dimensions, has apparently come into vogue, at any rate in non-mathematical circles, in consequence of these investigations of Riemann's. But it must be noted, that what he intended by the term *dimension* was not one or more axes of co-ordinates of the same order as the three Cartesian axes, and primarily applicable to space alone, but any distinct mode of calculating quantities in general, that is, effecting the actual measurement of aggregates of differences of any kind. "Riemann calls a system of differences in which one thing can be determined by n measurements an 'n fold extended aggregate' or 'an aggregate of n

[7] Von Helmholtz's paper already cited. Mind, Vol. I. (First Series) p. 309.

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dimensions.' Thus the space in which we live is a three-fold, a surface is a two-fold and a line is a simple extended aggregate of points. Time also is an aggregate of one dimension. The system of colours is an aggregate of three dimensions, inasmuch as each colour, according to the investigations of Th. Young and Clerk Maxwell, may be represented as a mixture of three primary colours, taken in definite quantities." [8]

Riemann in fact generalises, not space, but the idea of *dimension*, and with important consequences. For thereby space itself, in virtue of its being measurable, is brought under the general conception of measurable quantity, as a particular case of that conception, at the same time that, in virtue of its pure continuity, it can be considered simply as "a region of measurable quantities." (*Ibid.* p. 311.) Considered as an aggregate of points, or an aggregate of the three Cartesian dimensions, it would be a particular case of the general conception *measurable quantity*, while as "a region of measurable quantities" it includes within it, as a perceptual not a logical whole, all particular cases of measurable quantities, and would include itself among the rest, if it could in any sense be conceived as an aggregate of points. Two senses of the term *space* are thus clearly to be distinguished.

It is to the generalised idea of dimension, or quantity determined by dimension, not to space as a particular case of it, that is, as an aggregate of points, or an aggregate of three dimensions, and still less to space as "a region of measurable quantities," that the idea of *n* dimensions belongs.

[8] *Ibidem.*

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When the number of dimensions, that is, kinds of measuring operations determining quantities, is left undetermined, this is but another way of stating the fact, that the idea of dimension, measurement, or quantity, is generalised. Space as actually experienced continues in the last resort determinable, as before, by three dimensions and three only. It is the mode of approaching the question of its determination, and that only, which is altered. "Riemann showed . . . that the essential foundation of any system of geometry is the expression that it gives for the distance between two points lying in any direction from one another, beginning with the interval as infinitesimal. He took from analytical geometry the most general form for this expression, that, namely, which leaves altogether open the kind of measurements by which the position of any point is given."[9]

It seems, then, that the introduction of the conception of *n*-dimensional aggregates carries with it no suggestion that space, in that sense of the term which alone concerns either metaphysical or common-sense thought, may exist in more or in fewer dimensions than three, belonging to the same order or system as the three Cartesian dimensions. For these three alone are the inseparable co-element in the representation of Space as a continuous and infinite Vacuity, or "region of measurable quantities," within which must lie all those *n*-dimensional extended aggregates, or aggregates of differences of *n* dimensions, contemplated by Riemann's method, and apart from which they cannot be represented at all. The idea of an

[9] *Ibidem*, p. 310. Von Helmholtz gives the nature of this general expression in a note.

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extended aggregate of points, or of differences, presupposes the idea of a continuum, into which they are introduced. There is therefore a wide difference between the Cartesian dimensions of space in its entirety and the dimensions of any aggregate of points or differences, which must be conceived as particular configurations lying within space. The phrase 'space of *n* dimensions' is applicable only to particular spaces or configurations of space, and not to space in its entirety. We are applying it to the latter, and therefore applying it illegitimately, whenever we suppose it to imply the conceivability of a space or spaces, whether continuous with or separate from the space of our experience, which are determinable only by four dimensions (or any higher number) of the Cartesian order, that is, dimensions belonging to the same system with them. Speculations of this kind are by no means necessarily countenanced by the ideas or methods of the new geometry, which are based on generalising the conception, not of space, but of dimension simply as a mode of measurement.

Such speculations seem to have a different and far simpler origin. The natural desire to render any peculiar or unique object logically intelligible, by referring it to a place in some logical *scala generum*, is sufficient to account for them, if we also suppose that the object in question is taken as an existent reality, and that the enquiry into its metaphysical analysis, that is, into what it is known as being in actual experience, is omitted or neglected. In actual experience, as we have seen, space of three dimensions is known as the

single abstract percept framed by objectifying separately (so far as possible) one of the two formal elements of perception, time being the other; and this is a sufficient explanation of its being represented as having three and only three dimensions, without requiring, or even admitting, any further enquiry into the condition or the purpose, the *how* or the *why*, either of its nature or of its existence.

But if nevertheless some logical reason for its nature should still be sought for, this further and illegitimate enquiry would most probably begin by observing, that we can be said to have an intelligent understanding of a point in space only when we class it, either as the division of a line, or as determined by the intersection of two or more lines; of a line only when considered as the boundary between two surfaces; and of a surface only when considered as the boundary between two solids, or parts of three-dimensional space.

Looking at the subject in this way, the question very naturally occurs, whether, in order to give us a similar understanding of solids, or of any space of three dimensions, it is not necessary to suppose the existence of some space of four dimensions; and if so, then of spaces of any additional number of dimensions, each being necessary to render intelligible the existence of the space immediately below it in point of complexity. We are in fact then seeking a reason for the existence of space or spaces of three dimensions, by an extension of the process by which we have already rendered intelligible to ourselves the existence of space-determinations of two dimensions, space-determinations of

one, and space-determinations of none at all, that is, of surfaces, lines, and points.

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The question is natural, being the spontaneous offspring of the *intellectus sibi permissus*, which always seeks to explain its world *a priori*, out of whatever happen to be the latest acquisitions of its logical intelligence. In this sense the question is natural, but it admits only of an answer in the negative, so soon as we advert to the property of Infinity in all directions, which attaches to the Space of actual experience itself, as distinguished from any figured though three-dimensional space, which may be ideally carved out of it. For the supposed four-dimensional space, which in the first instance would be required to account for the existence of any particular solid figuration of three dimensions, must be conceived to lie within infinite space, if it is to be of spatial nature itself; and yet, if it does so, it cannot have more necessary dimensions than those three, by which the nature of that infinite space is characterised.

If, therefore, we attempt to conceive a space as the condition of any particular space of three dimensions, the attempt to conceive it as a space of four necessary dimensions breaks down, as being self-contradictory. If on the other hand we attempt to conceive it as the condition of the infinite space of experience, this attempt also breaks down in a similar manner, namely, because that infinite space, of which it is proposed as the condition, would then, as a conditionate, have to be conceived as finite, that is, as a particular space of three dimensions, which brings us back to the alternative just examined.

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Or put the matter thus. The supposed space of four dimensions, conceived as a condition of the possibility of the infinite space of experience, which is the conception the validity of which is in question, must lie beyond infinity, while at the same time, conceived as space, it must be itself infinite, and so share the characteristics of three (not four) dimensional space. As space it must be infinite, as condition of infinite space it must lie beyond infinite space, which is a logical contradiction. Yet if thought of at all, it must be thought of as a condition of three-dimensional and infinite space, seeing that we have no direct knowledge of it. The conception, therefore, is inevitably one of a self-contradictory nature. For observe, we cannot here think of infinities beyond infinities, or infinities of a higher order one than another, such as we have met with in algebraical calculations. It is of perceptual infinity that we are here speaking, resting on the simple fact, that no final limit to spatial continuity can be either presented in sense-perception, or represented in thought or imagination, but that all limits fall within that continuity, and have it beyond them, however far the process of limitation may be pushed. This perceptual infinity it is, which the three Cartesian dimensions exhaustively determine, but without limiting it, and which in turn sets a limit to the number of dimensions sufficient to determine it. If more than three were possible, three would not be sufficient for that purpose.

True, there is no contradiction between the idea of space and the idea of dimension, but this does not show that there is none between the idea of

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space and that of some particular number of dimensions employed for a particular purpose, when once our idea of space has received a definite meaning from experience. The consideration of there being no contradiction between the ideas of space and dimension is therefore irrelevant to the question under discussion, which relates to the particular number of dimensions which are necessary and adequate to the definite conception of space in its entirety. To answer this question, some experiential knowledge of space is plainly requisite, as a common basis of argument for or against any particular number of the dimensions necessary and adequate to the definite conception of it, every particular number being necessarily exclusive of every other. The above argument has accordingly been directed to show, that every other number of dimensions, necessary and adequate to the conception of space, but the number *three*, is contradictory of the experiential knowledge of space which is the common basis of argument, namely, the perception of it as an infinite all-embracing continuity. The matter lies in a nutshell. If the supposed space of four or more dimensions is not infinite, it is not space in the required sense, but is only a particular configuration within space; if on the other hand it is infinite, then its necessary and sufficient dimensions can be the three Cartesian dimensions only.

In order to exhibit the latter point, the case may be stated thus. Beginning with any one of our three Cartesian axes, say a vertical straight line, we proceed to the second by drawing another straight line crossing it at right angles at a certain point,

say a line from left to right horizontally. Next we construct the third axis by drawing, through that same point, a straight line crossing both the others at right angles, a line running forwards and backwards from the common central point. Now if we attempt to arrive at a fourth axis by the same method, or following the same law of construction, that is, by drawing a straight line crossing all the three former ones at right angles, and at the same central point, what we find is, that any such line, drawn at right angles to any two of the three already drawn, will always coincide with the third of them; that is to say, no *fourth* line belonging to the same order or system of axes can possibly be drawn. Consequently no space of four or more dimensions is conceivable, unless we give a new and special meaning to one or both of the terms *space* and *dimension*.

As the result of the whole argument we see, that Space, like Time, is incapable of generalisation. It is no special case or variety falling under a generic space. Nor again is Space itself a genus, or general concept; nor is there any such thing as a generic space, under which spaces of different species or varieties can be brought, distinguished one from another by the different number of their necessary dimensions, as their characteristic difference. Space is an unique, complex, and abstract Percept, though arrived at, it is true, partly by means of conception. Within it, or as parts of it, are contained whatever determinations or configurations may be distinguished one from another by specific characters, such as points, lines, surfaces, closed or partially closed solids, and the

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so-called spaces established by the methods of non-Euclidean geometry. It is true that these may be held to be specifically different varieties of some common genus; but from this it does not follow, that their common genus is the infinite Space of three dimensions, in which they are contained. The general term or concept *Determination, or Configuration, of Space* is the logical genus to which as species or varieties they belong. Moreover, even when so considered, it would be a mistake to imagine, that a space is generalised by adding to the number of its supposed necessary dimensions. It would on the contrary be rendered more complex, more specialised, more particular. A space of *n* dimensions, in the sense which we are now considering (supposing it conceivable), would therefore, on the analogy of the so-called spaces which we know, be far more highly specialised than a space of three dimensions; just as a space of three dimensions is more specialised than a surface, and a surface more specialised than a line. Every additional characteristic specialises that to which it is added.

Pure Vacuity is the highest geometrical abstraction, but not a geometrical generalisation. The highest geometrical generalisation is the conception of Determination or Configuration of that Vacuity, as already said. We obtain this, when we think of Vacuity as capable of receiving, or implicitly containing, all possible determinations, but containing none of them explicitly. The first or most general of all is identical with the simplest contrast or distinction, without which Vacuity itself would vanish from thought, I mean the

representation of a point somewhere within it. The highest generality next below this is the conception of a second point and the direction, or line, which joins them; and if in thought we identify the first point with ourself, then we think of the line or direction which joins it to the second, as a movement which we make towards the second point without deviation into any other direction; or in other words as a straight line, defined by Euclid, not as the *shortest* path between its termini, but as lying *evenly*, that is, preserving a single direction, between them. An angle formed by the meeting of two straight lines, such as that just described, is perhaps the highest generality next below this; which meeting determines a plane surface, of which the two meeting lines are boundaries. A line or path of movement in which the direction is distinguished from the line, and which is thought of as continuously changing its direction, though continuing to be self-identical as a line,—no two adjacent portions of it forming an angle with each other,—is called a *curve*.[10] And since the direction of such a line perpetually changes, plane surfaces may be wholly or partially enclosed by single curves, just as well as by a plurality of straight lines forming angles with each other. If we suppose a plane surface bounded by a curve to move in a direction at right angles to the plane, the curved line which bounds it will mark out a

[10] It is, I think, true, that the possibility of curves is open to objections precisely analogous to those which the Eleatics brought against the possibility of motion, objections drawn from our inability to conceive them, even in their minutest portions, otherwise than as angular, that is, as formed by the meeting of two straight lines having different directions. But this is not the place to deal with difficulties of this kind. The question belongs to the doctrine of Limits.

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curved surface. And in this way, by explicitly adding determination after determination, we may go on to the construction of solid figures enclosed or partially enclosed by surfaces plane or curved; each construction increasing in complexity and decreasing in generality with every added determination, in number without assignable limit. All the particular spaces created ideally by geometries, whether Euclidean or non-Euclidean, would thus be included as special configurations of one infinite homaloid Space. And every such particular configuration might be called a space of that number of kinds of measurement or determination, which had been necessarily employed in ideally constructing it.

Returning for a moment to Riemann's method and his "*n* fold extended aggregates," as described by Von Helmholtz, I see in them nothing incompatible with the conclusion just stated. Riemann, in the first place, makes his *n* fold extended aggregates depend on the number of dimensions which he uses in determining them; and in the second place, these dimensions are all taken ultimately from relations in positively perceived or imaginable space; and then thirdly, since the latter are expressed as algebraical quantities, and the reasonings concerning them have the form of purely algebraical calculations, it would always remain to be seen, supposing any calculation completed, whether the *n*-dimensional aggregate determined by it had or had not any significance in positively imaginable space, or in other words, whether the quantities arrived at were capable of a real, or only of an imaginary

interpretation. You may calculate the dimensions of a hippogriff algebraically, as well as construct the conception of it logically, without thereby, in either case lending it any perceptually verifiable reality.

My conclusion therefore is,—so far as a non-mathematician may venture to express one,—that Newton's absolute homaloid space remains, as before, the ground and the limit of all geometrical work, whether synthetic or analytic; and that this space is identical with what the metaphysician must understand by space, namely, homaloid, infinite, and of three and only three dimensions, which are those founded in and formulated from our original perception of an external world. The possibility that modes or formal elements of perception, other than that which we call Space, may exist for beings endowed with other faculties than ours, I would not for a moment deny. What I affirm is, that, though we may think of such modes or formal elements as analogous to, or in conjunction with, our known or knowable space, and consequently may speak of them in terms of space, yet no modes of dealing with our own space can render them either positively conceivable, or conceivable without logical contradiction, if spoken of in terms of space. *Space* means our space; and *our space* means space of three and only three dimensions.

A word must be said in conclusion on the expression "our space," as it is to ambiguities introduced into the words "our" and "we," by psychological assumptions, that a large part of the perplexities attaching to this subject is due. It seems, for instance, to be held by many, that, of the two

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so-called faculties or functions of the mind which are ultimately concerned in the apprehension of Space, namely, thought and sense-perception, thought is independent of sense-perception in such a manner, and to such a degree, as to be able to conceive specific kinds or determinations of space, which are not only unevidenced by sense-perception, but are incapable of being realised or construed to imagination founded on it. Thought seems to them to possess this independent power, in virtue of its admitted nature as the function of generalisation, combined either with our limited outfit in modes of sensitivity, or with the restriction imposed upon our perceptive powers by certain so-called *a priori* forms which are essential to their nature. The kinds or determinations of space which, in consequence of this view, are held to be conceivable by thought, while they transcend imagination and are incapable of verification by the senses, seem, therefore, to make part of a so-called noumenal, as distinguished from a phenomenal world; while those which are both construable in imagination, and thought of as possibly verifiable by human sense-perception, are rightly (though arbitrarily) included in "our" world, as objects of both kinds of faculties at once. I say *arbitrarily*, because it is difficult to see, if the thinking faculty or function which conceives the noumenal spaces in question is "ours," how the noumenal spaces themselves can fail to be "ours" also, notwithstanding that they are objects of one of our faculties only.

But the proof which I have now attempted to give, founded on experience alone (and therefore without the assumption of a thinking power

creative of its own conceptions), that the conception of space of n dimensions (in the ordinary sense of these terms) is a self-contradictory conception, would remove space of n dimensions even from that so called noumenal world, which is inaccessible to our perceptive and imaginative powers, but which may still be thought of as really existing. The conception of n-dimensional space would then fall back into the domain of simple illusion. And with it would go whatever support may have been derived from it for that conception of the universe, as divided into phenomena and noumena, or appearances and realities, wherein it filled an appropriate niche. The idea of noumenal (as opposed to phenomenal) reality is derived from the assumption of a thinking power capable of working independently of perceptual data.

The assumption or non-assumption of such a thinking power is, in fact, the pivot upon which this whole question ultimately turns. Since there is no contradiction between the conception of space and the conception of dimension, it seems at first sight to follow, that the conception of space is compatible with the conception of any number of dimensions. For why, it may be asked, should the number *three* be fixed upon as the only number of dimensions possible for space? Or again (in slightly altered shape), supposing space of three and only three necessary dimensions to be the only space given in human perception, why should we be debarred from conceiving any number of spaces, having each its own number of necessary dimensions, spaces which should be perceivable by other than human

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percipients, but yet thought of by man as having a real existence?

Now so long as the number *three* was supposed to be fixed upon in consequence of an *a priori* form of human perception in the Kantian sense, there was no answer to these questions. For the assumption of an *a priori* form of human perception involved that of separate psychological functions in man, each having its own form or law of activity (the proper name for which functions would be *faculties*); and therefore also that of a thinking, that is, a conceiving and generalising power, which, working under forms or laws of its own, independent of those of perception, was capable of framing, out of perceptual data, general conceptions of objects, not subject to the laws of that perception by which the data for its generalisations were furnished. Thus it was that thought appeared to have the power of conceiving space, not merely as a perceptual abstraction, but also as a logical and general abstraction, that is, as a logical entity, containing under it an indefinitely great number of specific spaces, each characterised by its peculiar number of necessary dimensions; or in other words, of hypostasising space in its entirety as a noumenal reality, though only one of the specific spaces, which as a genus it contained under it, that is, space of three dimensions, could become an object of human sense-perception, or of the imagination which was founded upon it. And to represent the number *three* as the only possible number of the necessary dimensions of space, then appeared to be a falsification of the true nature of space in its entirety, as conceived by thought, in-

asmuch as it was a representation of that particular space only, which human sense-perception was adequate to reveal.

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But if these initial and unwarranted assumptions, of an *a priori* form of perception, and of a separation between sense-perception and thought as two independent psychological functions, are dropped, and recourse is had to experience alone, we come to a very different conclusion. If to experience alone without assumptions we put the question, why the number *three* is fixed upon as the only possible number of the dimensions of space, the true answer is readily forthcoming. For then we have to ask in the first place, What we mean by *space*; what is the analysis of that complex percept, or if you like concept; in short, how do we define it? And in this way of approaching the question, analysis shows, as we have seen in detail in Book I., that it is a complex percept built up by perception and thought combined, and is of such a nature that three dimensions, and three only, are necessary and sufficient to define it, while, at the same time, being infinite, no other space can be conceived beyond it. Farther than this, or in contravention of this, thought alone has no power to go; its powers have already been employed in building up, and at the same time conceiving, the complex percept Space, and providing it with a definition. The supposed antagonism between perception and thought as independent functions is at an end, and turns out to be in reality a cooperation; whereas thought itself becomes its own antagonist, and involves itself in contradiction, when it attempts to set up the possibility of

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so-called n-dimensional space in contravention of its own conclusions, arrived at in combination with perception. It is self-contradictory to subsume space under itself, as a particular under a general term. The space of perception and thought combined is incapable of being generalised, that is, converted into a logical universal. The next highest general term, under which space falls as a particular case, is not space again, but *continuity;* time being the only other positively known continuum, of equal rank with it in point of abstraction, belonging to the same head.

Leaving the consideration of so-called space of n dimensions, I turn once more to those particular configurations or modes of configurations of space, which are known as the creations and objects of non-Euclidean geometries. These stand on a very different footing from that of so-called n-dimensional space. They involve, so far at least as I can venture to form an opinion, no contradictory conceptions, but are perfectly valid as ideal constructions introduced into, or as it were carved out of, space, considered as in itself indifferent to any configuration of divisions or boundaries demarcating one portion of it from another. Nevertheless, they do not share with the space which may be considered as the creation and object of Euclidean geometry the property of being co-extensive with that infinite space, which is of necessity the field which Geometry has to cover.

When, therefore, we put the question, with regard to these particular non-Euclidean spaces, whether they or any of them can in reality be "our" space, the answer must be No. The reason

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for which answer is, not that they do not correspond to, or are incompatible with, the laws of physical Nature, or that physical phenomena are not conformable to their ideal constructions (for this, it would seem, we have no sufficient means of ascertaining), but that they fail to satisfy that conception of space which our thought educes from the data of sense-perception, I mean the conception of it as infinite in all directions. "Our" space must be that in which thought and sense-perception combine to show, that we actually live and move; and this, I have tried to prove, can be no other than that infinite Vacuity, with which the physical world of Matter may possibly turn out to be conceivable as co-extensive (a point on which it is not here the place to express an opinion), but which it cannot possibly be conceived to transcend. The ideal determinations of space, not the laws of physical matter or force occupying it, are the object-matter of pure or abstract Geometry. The determinations which matter and force introduce into space are an object-matter, the nature and laws of which pure Geometry may be applied to ascertain, precisely because its own determinations, being ideal, can be ascertained in abstraction from them.

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§ 7. Enough perhaps for the purpose of the present work has now been said of time, space, and abstract motion, with the sciences of measurement to which they give rise, Calculation, Geometry, and Kinematic; sciences which, as compared to those which deal with objects in the concrete, may be classed as purely mathematical. It remains to consider Matter itself, that concrete physical

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existent, with the nature and laws of which the less abstract positive sciences are concerned; the events which take place in and between material things constituting that order of real conditioning, which is the object-matter of scientific analysis. We have seen what matter is on the subjective side, or as known by our objective thought of it, in Book I. Let us now see what it is on its objective side, or as a physical existent possessing reality in that fullest sense of the term which is distinguished as the reality of *real conditions.*

Now the first thing which has to be noted in matter as a physical existent is, that it is an instance of the inseparability of distinct elements, analogous to that inseparability of formal and material elements, which we have already found to be universal in perceptual experience. Matter as a real condition also shows an inseparability of distinct elements, but elements of another kind. That solid tangibility which we call matter includes force, and cannot exist as matter without it. Similarly there is no such thing as force, unless it be inherent in or exerted by matter. Neither matter exists without force, nor force without matter. Try to imagine free or pure force, I mean free or pure from matter, and as it were *in vacuo*;—it cannot be done. At every attempt to do it, some substance or agent possessing and exerting it is supplied in thought, and this substance or agent is thought of as analogous to matter. Or take matter, and try to imagine it pure from force. Again you fail. Its very coherence or consistence as matter, or solid tangibility, is force. It is force whereby it exists as solid tangibility. And this holds good of the

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ultimate atoms or particles of matter, supposing them to be assumed as separable existents, just as much as it holds good of matter in any other form, whether in that of a configuration of atoms, with aggregation of molecules, or in that of a continuous medium filling their interstices, and extending indefinitely into space beyond them, or in that of a continuous medium, in which rotatory or other motions are the ultimate constituents of whatever can be called material bodies.

Force, then, is one of the inseparable constituent elements in matter. But what is the other, or others if more than one? Our previous analysis shows that there are two and two only; one the element of time-duration which matter, like all existents without exception, must occupy if it exists at all, and the other the element of spatial extension in three dimensions, though this is not so wholly simple and unanalysable as time. In all cases where matter is perceived or thought of as perceivable, what we so perceive or think of is some portion or portions of three-dimensional space, each coherent within itself, and offering resistance to touch or pressure from without. Wherever three-dimensional space can be tactually felt or thought of as being felt, we have matter presented or thought of as real; and any portion of it which can be so felt is said to be occupied by the matter which coherently fills it. Nothing further is needed to satisfy our conception or experience of it. The space occupied, and the felt occupancy of it, or what is the same thing, three-dimensional extension and force, are thus the two inseparable,

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sufficient, and indispensable elements distinctive of real matter.

It is from its spatial element that we gain the first rudiments of the measurement we apply to it. From this element is derived the first step towards the idea of a *quantum* of matter, that is to say of mass. A quantum of the space occupied taken alone is volume; and the volume together with its occupancy, that is, the matter occupying the volume, is mass. Every portion of matter must, as an actually existing individual thing, have both mass and volume; that is, there must be both some particular quantity of it, and of the space which it occupies. But the quantity need not vary with the volume, the quantity of matter with the quantity of space which it occupies. Equal portions of space may be occupied by different quantities, that is, densities, of matter. The density of matter in a given volume is its mass as distinguished from its volume. Moreover, "Matter is measured by what the mathematician wants to force the world to call the Mass, but this the Metaphysician, in common with the rest of the world, calls the Weight"[1]; words which refer to a passage which had just been quoted from Clerk Maxwell's "Theory of Heat," in which we read that "few or none of them" [the

[1] From an admirable paper by Professor A. G. Greenhill, F.R.S., *The Measurement of Space, Time, and Matter*, in the Proceedings of the Aristotelian Society, Vol. II., No. 2, Part I., page 49, 1893.—One metaphysician, at any rate, is quite content to think and speak with the mathematician on this point. At the same time it must be noted, that, since the quantity of matter is not immediately accessible to sense-perception, mass can never be directly measured. The case is similar to that of time-lengths, noticed above. Its measurement is arrived at indirectly, by means of what it does, or the effects due to it; most readily and universally by means of weight, which is its action under the law of gravitation, by comparing equal volumes of matter under the same conditions of altitude and temperature. Mass or quantity of matter is therefore said to be, not identical with, but always proportional to, weight. In this way units of mass may be selected; as for instance, the quantity contained in one cubic centimetre of water at 4° Centigrade temperature.

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metaphysicians] "perceived that the sole unalterable property of matter is its mass."[2] In minima of matter, that is, strictly ultimate particles or atoms of it, supposing them to have a separable existence, and the matter to be homogeneous, the relation between mass and volume would be constant.

There seems also to be a limit, in the direction of divisibility, to the volume which is one of the indispensable elements of matter, and therefore to matter, or mass, itself as a real existent. At first sight, since any portion of pure or abstract space is ideally divisible *in infinitum*, being pure continuity, it seems as if the matter occupying it might be conceived as divisible *in infinitum* also. But when we consider what is involved in the occupancy of space, it becomes evident that it is impossible so to conceive it. Occupancy of space involves coherence or cohesion of the parts occupied. Two portions at least of space are therefore requisite for coherence of parts, and consequently for the material occupation of any portion of it. Neither of those two contributory portions of space taken severally (whatever may exist in them) are or become a portion of matter, but only the two taken together.

This is a result of analysis which forcibly reminds us of those empirical minima of perception or consciousness, commonly called *minima sensibilia*, which we came upon in analysing reflective perception (Book I. Chap. II. § 5), empirical minima, the duration of which was only ideally divisible. But there is the following important difference. Consciousness is ideally divisible *in infinitum*, equally

[2] *Ibidem*, p. 45.

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with the time-duration which it occupies, that is, without the parts of either of them ceasing to be, the one parts of time-duration, the other parts of consciousness, notwithstanding that the parts so arrived at are in neither case severally perceivable by sense; so that we are not driven to suppose a minimum of consciousness composed of parts which are not-consciousness. In matter on the other hand, two parts (at least) of three-dimensional space must be conceived as distinct from and co-existing simultaneously with each other, before we can conceive the existence of even the smallest portion of matter; in saying which we are speaking, not of the smallest portion empirically perceivable, but of the smallest portion which can be ideally or mathematically conceived, or rather of any portion, large or small, provided only we do not leave out of view its fundamental characteristic, namely that of simple space-occupancy. The extension element even in ideally conceived matter is ideally divisible farther than the ideally conceived material element in it, however far we may go in the ideal division of that material element. In other words, the mathematical or ideal division of matter into smaller and smaller portions affords no means of escape from this property of its nature as matter. If it occupies space at all, it must occupy at least two contiguous portions of it simultaneously; and this is a property of its nature as space-occupancy, a property which we arrive at by analysing it into its constituent elements, and not by any consideration of the relative magnitude of the portions which we may successively take for analysis.

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Consequently we must conclude, that there is what may be called a *minimum physicum* in the world of matter. We cannot conceive matter, as we can conceive consciousness, divisible *in infinitum.* However far we may push our ideal division of any portion of it, there are always two parts of that portion, neither of which severally is matter. In successive divisions, it would cease to be matter, before the space occupied by it ceased to be divisible. We must therefore conceive, that, whenever and wherever matter exists, it must occupy some magnitude of space, that is, have some volume, which is finite in the direction of divisibility, however small or however large that volume may be. Nothing is thereby implied concerning its magnitude in the direction of increase; neither can what I have called the *minimum physicum* be identified with the conception of atoms in chemical theory, a conception which stands on a perfectly independent footing. Whatever portion of matter we contemplate, provided we conceive it as formed by the inseparable union of its indispensable constituent elements, and so reduce it in thought to its lowest terms, seems to spring into existence, we know not how or whence; though if, *per impossibile,* we could imagine stresses existing previously and alone, we might fancy it to be the product of opposite stresses, and not merely itself analogous to a single stress. That is to say, its coming into existence is a problem, and one which we have no apparent means of solving. Its real genesis is for us a "final inexplicability." We shall recur to this point in § 9, on *Empirical Matter.*

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Briefly to resume the foregoing argument:—Matter is always divisible in thought, because it occupies space; but since it always consists of two portions of space at the least, it follows, that it is not infinitely divisible without ceasing to be matter, as space is infinitely divisible without ceasing to be space. Owing to its element of Force, it is not a simple continuum, but a compound of two (or more) continua in interaction; there is action and re-action in every particle of it. There is thus some finite minimum of volume which matter must occupy, if it is to exist as matter at all. We can only say of it, that it is divisible *in indefinitum*, not *in infinitum;* but this we must say of it, seeing that all our means fail us of analysing empirically given matter beyond a certain point, a point short of arriving at a demonstrated minimum.[3]

Turning in the next place to the other inseparable constituent of matter, that is, to force as distinguished from the three dimensional extension which it fills, or to the occupation of space from the space occupied, or again to the cohesion of parts from the parts which cohere, we see at once that it is this constituent of matter which differentiates its reality as real condition from the reality of those objects thought of which are conditionates only. The force in matter is the objective fact to which the objective thought or conception *real condition* applies, and the reality which it expresses. It is the *differentia* of objects which are real conditions. The term *force*, therefore, is a general expression for that efficiency which is present in and upholds the Course

[3] Perhaps I should here refer to my Address on *Matter*, Nov. 1891, for an earlier sketch of the view here taken. Published in the Proceedings of the Aristotelian Society, Vol. II., No. 1, 1892.

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of Nature; of which the mechanical interaction between coherent portions of matter is the lowest and simplest form; this interaction being made known to us originally in cases where our own body is one of the portions of matter concerned, and subsequently interpreted by the light of that experience, and described in terms which derive their meaning from it. Here at length for the first time we come upon activity, agency, or efficiency, in things known; and of this simplest and lowest form all others must be conceived as specific modes or varieties.

Force, therefore, being an inseparable and ultimate element of matter, and not being in that character farther analysable, (though, as will hereafter be seen, we can analyse the mode in which our conception of it in that character is arrived at), does not strictly speaking admit of being defined, as the concrete existents do, namely, particular volumes and masses of matter, into which it enters as a constituent. Like feeling in the subjective aspect of experience, its specific nature is incapable of definition, and for a similar reason, namely, that it is an abstract, ultimate, inseparable, and unanalysable element of the concrete existents which it contributes to constitute, and yet in that general character as an element is unique, an unique perceptual element which can only be understood by being perceptually experienced. Like feeling, it is not an empirical existent, but an element of existents. Also, just as in the case of feeling, to enumerate and contra-distinguish its varieties is not to define it. But this does not detract from the reality of its specific modes, any more than from that of the specific modes of feeling, every one of

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which escapes definition in precisely the same way. And the reality of force, as we have just seen, is reality of a specific kind, the reality of an agency or efficiency in the concrete existents into which it enters, and which it contributes to constitute. It is, in real matter, the element which corresponds to the *fact that* matter is felt, in the perception or objective thought of matter. But there is no single and specific percept answering to either of the general terms, *feeling* or *force.*

Hence when we try to express in words our conception of its nature as a reality, that is, to come as near to a definition of it as possible, we can only do so by assigning, not what it specifically *is*, but what it specifically *does*, or rather what the concrete matter does, of which it is the action or activity. Matter including its inherent force may perhaps be described as the adverse and active occupancy of space; just as matter, abstracting from its inherent force, might be described as the occupancy of space simply. But the activity spoken of must of course be conceived as internal, or confined within the limits of the space occupied, so long as we are dealing only with the nature of matter and force, and not considering the relations which may obtain between separate or separable masses.

Force in common-sense experience is the plainest and most irresistibly obvious of phenomena. It is the perception of tangible resistance, touch with sense of effort, push and counter-push, pull and counter-pull, between our own organism and solid bodies external to it. Subjectively we may characterise it as *feltness*, something *felt.* But when it comes to be defined, for the purposes of science,

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when we ask what pushing or pulling *is*, which is felt as tangible resistance, or touch with effort,—then it seems, that this thing which we call force *is* nothing and yet *does* everything. It is the doing, activity, or behaviour of matter, or rather of mass, a *quantum* of matter; or mass as *doing*, distinguished from mass as *being;* or one of the two components or elements of mass; or mass *engaged in completing* a portion of time, as distinguished from mass in abstraction from its continuance. It is the existing of an existent; the *fact that* it exists, and exists as an agent; not the cause, but simply the fact of the existence of matter and of mass. This excludes the idea, that force is self-existent, or creative of matter, or a noumenal entity of which matter is the manifestation. It means, that the origin or creation of matter, whatever it may be, is also the origin or creation of force, since matter and force inseparably involve each other.

A few words must be added in order to contrast this view of matter and force with that which has come down to us from Scholastic times and from pre-Scholastic sources. Matter we have seen is ultimately describable as two (or more) contiguous portions of space simultaneously occupied; and Force as the simultaneous occupation of two (or more) contiguous portions of space. Matter is space occupied; Force is the occupation of it. Material or physical substance, therefore, which is space occupied in one mode (which for convenience we may call the statical) by matter, and in another mode (which we may call dynamical) by force, is always active or agential substance. That is to say, matter is agent; force is its agency. But in

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this substance, matter and force, being but the two modes in which the space-occupancy, which is common to both, takes place or consists, are as inseparable from each other, as both alike are from the space which they occupy together. You cannot conceive either as existing separately, apart from the other, without illegitimately hypostasising it, and making an entity of an abstraction. That is, in other words, you cannot, except by confusion of thought, take matter *per se* as a real but passive or inert substance, acted upon *ab extra* by force *per se*, as a real and active agency; nor can you take force *per se* as an instrument wielded by matter, as if matter without force was a real and active agent. Force, it is true, is agency, but it is the agency constituting matter; matter is agent, but the agency, in virtue of which it is an agent, is force.

The case is analogous to what we have already noticed, when analysing consciousness in time alone. Just as in consciousness the time element in the consciousness is identical with the consciousness as a process, so here in matter, the force element in the matter, which I have just called the dynamical mode of its space occupancy, is identical with the matter as a process, that is, with the doing or action of matter. The additional characteristic by which, in common-sense thought, we are accustomed to distinguish what we call physical action from physical process, is an importation from experiences in which our own sensitive organism is one of the masses of matter concerned, and is ultimately due to the sense of effort or tension involved in those experiences. Apart from this feeling, or others closely associated with it, such as those

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arising from cutting, rending, and so on, which are proximately conditioned on our own organism, there is no difference between physical action and physical process. Except by attributing feeling to matter, there is no ground for drawing a distinction of kind between them. Action and re-action together constitute action and process alike.

Now the view which has come down to us from Scholastic and pre-Scholastic times, and which I imagine is still widely prevalent, both in scientific and non-scientific circles, is very different from the foregoing. It has two branches. In one of these it consists in first hypostasising matter as substance apart from force, that is, as some reality supporting attributes or properties, and then saying, that what this substance is in itself, or *an sich*, is unknowable, seeing that we only know the attributes or properties, which are its phenomenal manifestation. In the other branch it consists similarly in first hypostasising force as agency, as some real power acting upon an hypostasised matter, and then saying, as before, that what this real power is in itself, or *an sich*, is similarly unknowable, since we know only its phenomenal effects. It consists, in short, in first setting up two fictitious noumenal entities, made out of abstractions, and then admitting that no positive idea can be formed of them. People are not unfrequently found who pride themselves on their philosophical acumen, when they succeed in recognising, that the so-called noumenal reality, or *an sich*, of matter and force is unknowable; not seeing that the reason for its being so is, that it is a fiction of their own inventing. It is true, that the existence of matter and

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force as inseparable modes of space occupancy, that is, of material or physical active substance, is for us a final inexplicability, and one which compels us to recognise, that it depends upon something or other which we class under the head of real condition, but which we cannot positively conceive. But then that real condition is unknowable in a very different sense from that in which a pure fiction is unknowable. It is thought of, not as a noumenal entity unknowable *a parte rei*, but as a phenomenal reality, whose *esse* is *percipi*, like that of all realities, only that it is one which is not within the reach of human sensitivities.

§ 8. *Vis insita; Vis inertiæ; Vis impressa.*

§ 8. The force which I have thus attempted to describe I apprehend to be the same as Newton's *vis insita*, or (same thing again) his *vis inertiæ*, as given in the Third Definition in his *Principia:* "Definitio III. *Materiæ Vis Insita est potentia resistendi, qua corpus unumquodque, quantum in se est, perseverat in statu suo vel quiescendi vel movendi uniformiter in directum.*"—"The inherent force of matter is a power of resisting, by which every body, as much as in it lies, perseveres in its state, either of rest, or of uniform motion in a straight line." And the remarks on this definition begin as follows: "*Hæc semper proportionalis est suo corpori, neque differt quicquam ab Inertia massæ, nisi in modo concipiendi. Per inertiam materiæ, fit ut corpus omne de statu suo vel quiescendi vel movendi difficulter deturbetur. Unde etiam vis insita nomine significantissimo Vis inertiæ dici possit.*"—"This force is always proportional to the body it inheres in, nor does it differ at all from the inertia of mass, except in our way of conceiving it. By the inertia

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of matter is brought about, that every body is only with difficulty disturbed from its own state of rest or motion. Whence also *vis inertiæ* is a most significant name for *vis insita.*"

It is plain from this, in the first place, that Newton conceives the force he speaks of as an inherent and universal property of mass, that is, of every *quantum* of matter; and, since there is no matter which has not quantity, as an inherent and universal property of matter also. Secondly, since he admits no mass or matter without it, there is consequently for him no such thing as dead or inert mass or matter, as deadness and inertness are popularly apprehended. He decisively negatives the common-sense notion of deadness or inertness in matter. The inertia of mass and consequently of matter, which Newton speaks of, is not inertness but force. Inertia itself is force. It is true, as we shall presently see, that this force is known only by what it *does*, or as a *doing* of something. But, inasmuch as it is always inherent in mass, it is not free or pure force without an agent. Mass is the *doer* or agent, and its whole doing is force.

It is here, in fact, from these luminous and accurate words of Newton, that we gather the physicist's ultimate conception of force. It is here, so to speak, that we run it to earth. For it appears here as that which (1) cannot be got rid of out of mass or matter, and (2) is of extreme simplicity, not as yet modified or specified as force of this or that kind, a doing of this or that. The conception of it is applicable not to ponderable matter only, but to matter of any and every kind, say, for instance, the commonly assumed all-per-

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vading ether, whether it be ponderable or not. Whatever is conceived of as a resisting solid, or composed of resisting solids, in the geometrical sense of *solid,* namely three-dimensional, is conceived of as matter. And in whatever is so conceived, force must also be conceived as inherent.

Let us now see what the doing of the force consists in. I quote the words next following those already quoted from the remarks on the Third Definition: "*Exercet vero corpus hanc vim solummodo in mutatione status sui per vim aliam in se impressam facta; estque exercitium ejus sub diverso respectu et Resistentia et Impetus: resistentia, quatenus corpus ad conservandum statum suum reluctatur vi impressæ; impetus, quatenus corpus idem, vi resistentis obstaculi difficulter cedendo, conatur statum ejus mutare.*"—"Now a body exerts this force only in the change of its own state which is wrought by another force impressed upon it; and its exertion is both resistance and impetus, but in different respects. It is resistance so far as the body relucts against the impressed force so as to maintain its own state; and it is impetus so far as the same body, in yielding with difficulty to the force of an obstacle resisting it, endeavours to change the state of that obstacle."—In other words, the force of inertia is always present, but is exerted only when a force, external to the body or mass in which it is inherent, is in some way brought into relation with that body. Then it is called forth into exertion, and the body re-acts partly in resisting change of its own state, and partly in effecting change on external bodies. In re-action on external bodies its *vis insita* becomes

vis impressa, exerted, namely, on the external body or bodies, just as the action of the external body, which was taken as first acting on it, was *vis impressa* exerted upon it.

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The force and its exertion are not the same thing; and yet in one sense they are the same, since the one is the exertion *of the other*. The force, *vis insita* which is also *vis inertiæ*, is acted upon by a *vis impressa*, is exerted when so acted upon, and its exertion both as resistance and impetus is *vis impressa*. The exertion of *vis insita* is *vis impressa*. Let us see what Newton says of *vis impressa* in the next Definition. "Definitio IV. *Vis impressa est actio in corpus exercita, ad mutandum ejus statum vel quiescendi vel movendi uniformiter in directum.*—Consistit hæc vis in actione sola, neque post actionem permanet in corpore. Perseverat enim corpus in statu omni novo per solam vim inertiæ. Est autem vis impressa diversarum originum, ut ex Ictu, ex Pressione, ex vi Centripeta."—"Def. IV. *Vis impressa* is an action exerted upon a body to change its state either of rest or of uniform motion in a straight line.—This force consists in the action only, and does not remain in the body after the action. For a body perseveres in every new state by *vis inertiæ* alone. Also *vis impressa* has divers origins, as from a blow, from pressure, from centripetal force."

§ 9. We have, then, these three things, *vis insita*, *vis inertiæ*, and *vis impressa*. These three are partly the same thing, and partly different things. *Vis insita*, Newton says, differs from *vis inertiæ* only in our way of conceiving it. But what is this

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difference? It is plainly this. *Vis insita* belongs to mass, or to matter, when the latter is considered *per se*, that is, either as matter generally, or as a particular material thing, but in abstraction from its relations to other material things with which it is connected, or may be brought into connection. This same *vis insita* is *vis inertiæ* when we replace it in the relations we had abstracted from, and consider it as acted upon by other bodies external to that in which it is taken as *insita*. They are thus the same force differently considered.

Next as to *vis impressa*. This is the exertion of *vis insita* or *inertiæ*, when bodies are taken in relation, and acting one upon another. Not a new force, but the exertion of the force previously defined as unexerted. The three things, then, are (1) force inherent in matter simply, *vis insita;* (2) force inherent in material things acted on by other material things, *vis inertiæ;* and (3) force exerted by material things upon one another, *vis impressa.*

Vis inertiæ is the central or connecting link of the three. A force external to a body could not act upon the body as *vis impressa*, if there was no force in that body upon which to act, that is, if the body had no *vis inertiæ*. But the central link of the three, *vis inertiæ*, could not exist unless it were founded in the nature of the body it belongs to, as *vis insita*. Nor again could it re-act on the body impressing it, nor exert *vis impressa* or other bodies, unless they, like it, offered something to be acted on, that is, were like it possessed of *vis insita* and *vis inertiæ*.

But now to come to closer quarters with that cardinal idea of action, activity, agency, or efficiency,

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which, as already said, is the essential element of the term *Force*. It will be found, if I mistake not, that the empirically perceived fact of motion is necessarily prior, not indeed to the real existence of force, which is a constituent of matter, but to the formation of our conception of force, as action or agency. We know to begin with, that is, as a common-sense and pre-scientific datum, that the material world consists of material things numerically different, and in states of rest and motion, which are perpetually changing relatively to one another. It is these empirical phenomena which are the starting point of all physical and positive science, just as the empirical phenomena of consciousness (among which these when taken subjectively are included) are the starting point of metaphysic. Moreover we see, that Newton's Third Definition implies, that matter may be taken to exist originally, in any case which we may happen to be examining, equally well in a state of motion as in a state of rest. Consequently *vis impressa* in relation with *vis inertiæ* is that which physical science practically begins by dealing with. The other aspect (so to speak) of *vis inertiæ*, in which it is in relation to *vis insita*, and also this relation itself, are of no practical import in scientific reasonings; for they are facts or truths which are common and indifferent to all actions, of every kind, between bodies, and remain unaffected whatever those actions may be. Their importance is simply theoretical, that is, requisite to our intellectual understanding of the phenomena. But as theoretical they are indispensable, being fundamental truths. And if definitions are given which

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contravene their theoretical requirements, confusion must sooner or later be the result. The great philosophical merit of Newton's treatment of these distinctions consists in the clearness with which he shows how the *operations* of matter are founded in its *nature*, thereby precluding a recourse to imaginary ontological entities operating *ab extra* upon matter in its entirety, or interfering *ab extra* with the interactions between its parts. But this point being made clear, and this foundation being firmly laid, Newton then passes at once to *vis impressa* in relation with *vis inertiæ;* and this he does when he begins the body of his great work with the *Axiomata, sive Leges Motus*.

Matter of all kinds, ponderable and imponderable, continuous or separated into masses numerically different, and motions of all kinds, severally belonging to the several kinds of matter, which several kinds of motions are commonly known as the various specifically different Forces, or more properly Energies, of Nature, collectively constitute the empirical object-matter or *explicandum* of the Positive Physical Sciences. But since in these phenomena motion is an ultimate fact or datum, a fact or datum equally primordial with rest, and yet we have now found, that force, in Newton's sense of the term, is an essential constituent of matter or mass, when taken in abstraction from both these facts, the question is inevitably raised, how we are to conceive the relation which obtains between force on the one side and these two primordial data of experience on the other. And here is the place to give a definite though brief answer to this

question. First, then, as to the relation between force and motion.

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Plainly the analysis of matter is the test to which we must appeal, matter being the common ground on which force and motion meet, and on which therefore the relation between them must be determined. Basing ourselves upon the analysis of matter in its lowest terms, as a case of simple cohesion, given in § 7, we find it impossible to conceive either force or motion, as being either the cause or the effect of the other. The matter analysed in § 7 was matter taken in its lowest terms, that is, irrespective of its continuity or discreteness, and therefore also of the state of relative rest or motion of its discrete portions, if any. And of matter so taken our analysis showed that force was an essential constituent. But this makes it impossible to suppose, that this same force, that is to say, force in its utmost simplicity, is also the cause of motion as distinguished from rest. For this would require us to suppose, either (1) that matter could exist independently of force, prior to motion arising in it;—which would both contradict the analysis which showed force to be essential to the existence of matter, and substitute for it the assumption of matter existing originally in a state of rest or inertness;—or else (2) that force causes motion in causing matter to exist; which equally contradicts the analysis, and substitutes for it the assumption of force being a transcendent agent creative of matter, instead of being a constituent element in it. Force, therefore, can never be conceived as the cause of motion. Neither on the other hand can motion be conceived as the cause of force, seeing

that motion cannot be conceived to exist apart from matter, of which force is a constituent.

It therefore remains for us to conceive the relation of force to motion as the relation of a more abstract to a less abstract attribute of matter; motion being empirically the more obvious and less abstract attribute of the two, inasmuch as it can be empirically distinguished from rest, while force is involved both in rest and motion, and is distinguishable, not from any other attribute of matter (other than the purely formal elements of time and space), but only into two or more forces, or (in the extreme case) components of force, in antagonism to each other; as shown by the analysis of that ultimate fact of cohesion, in § 7, between two or more distinguishable portions of space, which in the last resort constitutes matter as space occupancy.

The terms *force* and *motion* are therefore names for the two different degrees of abstraction, with which we conceive one and the same fact or attribute of physical matter; *force* being the name for it when conceived as escaping sense-presentation and yet as an essential and inseparable constituent of matter itself. It is the name for tendency or tendencies to motion in matter, any one of which, the moment it is thought of as separately presentable to sense, is thought of as the opposite of *rest*, or in other words, is thought of under the less abstract conception of *motion*.

We want the empirically perceived fact of motion to enable us to form the conception of two oppositely directed tendencies to motion, that is, of force; and we want the conceived fact of force to enable us to understand the existence of

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matter, in either of its empirically perceived states of rest or motion. Two tendencies to motion, in two opposite directions, which are not yet motion, must be conceived to co-exist at a common limit, before we can conceive the existence of matter, of which both motion and rest are states. Thus force is a fact which can only be conceived by first conceiving an abstract feature (tendency to motion) in a fact which is less abstract and is perceivable by sense (empirical motion); both facts being abstract features, arrived at, one by simple attention, the other by analysis, in empirically perceived matter. Motion, then, is not, like force, an ultimate constituent of matter. Like its contrary, rest, it is a state in which matter exists, not a constituent element of it. And rest and motion are states which are both mutually exclusive, and an exhaustive division of states of matter; that is to say, they are states into one of which any portion of matter must pass, if it passes out of the other, and in one or the other of which it must exist at any single given moment.

The conception of the force which constitutes matter thus rests upon the empirical experience of motion; inasmuch as it involves the idea of a tendency to motion in one direction, met and balanced by a tendency to motion in the opposite direction. The empirically obvious idea of motion is in fact that, by means of which our idea of force is framed. We cannot realise in thought the idea of force, without laying the idea of motion at the basis of it. From this follows the relation of force to rest; rest being conceived as that state of matter, in which either two or more opposite

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forces, or two or more opposite tendencies to motion, are in equilibrium, or exactly balance one another. So long as we conceive a single particle, or any single mass of matter (abstracting from the internal relations of its parts), existing in isolation, we conceive it at rest. Matter in its lowest terms, and conceived in isolation, is the equilibrium of equal and opposite tendencies to motion. An aggregate of masses, or portions of matter, similarly conceived, is the equilibrium of equal and opposite forces.

At the same time it is only as either constituting matter, or displayed in the interactions of matter, that either forces or tendencies to motion can be conceived to exist. From which it follows, that a single tendency to motion, or a tendency to motion taken alone, is not force as we positively know it, that is to say, as first constituting and then operating in matter. A tendency to motion becomes force only when resisted by another tendency to motion oppositely directed. Resistance makes it force, in making it Conation. In all force there is effort; that is, there is Conation. This force it is which is constitutive of Matter, both in its entirety, and down to its minutest particles, and of which there are as many distinct kinds as there are distinct kinds of matter, possessing each its distinctive set of properties.

It is the first brief fundamental part of Newton's work, containing the establishment of *vis insita* and its relation to *vis inertiæ*, and through this to *vis impressa*, together with the nature of the relation which obtains between force on one side and motion and rest on the other, which alone possesses

a special interest for the metaphysician. It is this which contains the connection between science and philosophy. It is this which deals with what the metaphysician calls the *nature* of matter and the material world, as distinguished from, and yet connected with, their *order of real conditioning.* That force and matter are inseparable and mutually involved, and that this intimate union alone renders intelligible the action of bodies one upon another, and the changes which the bodies undergo in consequence, — these are the facts which specially concern metaphysicians, and the exposition of which by the genius of Newton is in admirable harmony with the conceptions and methods of subjective analysis.

The line which demarcates the *nature* of matter from its genesis and history, and therefore demarcates also its philosophy from its science, is no line of separation; it is a line of distinction; running, so to speak, right through the conception, and the fact, of *vis inertiæ. Vis insita* and *vis inertiæ* on one side; *vis inertiæ* and *vis impressa,* which of course includes all *vires impressæ,* on the other. On the one side we have what matter *is.* On the other we have the ways in which different kinds, and different portions, of matter operate *inter se;* their motions and states of equilibrium or "null motion"; the "work" they do; their energies and transformations of energy, potential and kinetic. And the two great laws of Dynamic, those of the Conservation of Mass and the Conservation of Energy, follow directly from Newton's conception of force applied to the case of portions of matter in relation to each other. And as with matter, so

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also with force. On one side of the demarcating line we have force as inherent in matter simply; on the other we have the various modes or kinds of energies which spring from force, the "forces of Nature" as they are popularly called, with their transformations or correlations, one with another; or in other words, the whole *de facto* concrete Course of Nature, the explanation of which consists in its being referred to the general facts or laws, under which its phenomena are grouped according to their respective affinities.

§ 10. Only the Perceptual Order is Real.

§ 10. A word in retrospect of the present Chapter. If we are right in saying, that science is born at the moment when the conception of real condition is first consciously applied in the discovery of laws of Nature, it will also be true, I think, that it completes its initial stage, and is fully constituted as scientific method, when it applies any knowledge, won by its own conceptual processes, to the facts of Nature in their actual order of existence and occurrence, this order being an order of perception, not of thought. Mathematic may be called the Special Logic of science. And mathematic, in its two branches of geometry and calculation, is an analysis of phenomena in their time and space relations; that is to say, the relations in which they are objects of perception as distinguished from thought. The conceptual process is instrumental and intermediate. It begins with perception simply, and it ends with perception again, in the sense, that it gives us back the time and space relations between objects which are conceived as objects of possible perception, that is, of perception which would be actual, supposing our

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sensitivities were sufficiently acute to be affected by them, or the necessary opportunities were offered for observing them. What we mean by the real and actual order of Nature is always Nature, not as conceived simply, but as conceived to be perceivable; not with its phenomena merely grouped as phenomena of different kinds, as heat, electricity, gravitation, and so on, but with its phenomena of these different kinds intertwined, and mutually determined, co-existing and occurring in close union and interfusion one with another, and forming in this union a multitude of closely connected existents, which are, logically speaking, singulars, each existing once and once only in the Universe of Nature, which is the (logically singular) totality of them. We group them into classes by conception, but it is in order to know them in their real, that is, their perceptual relations. Nature's grouping is the perceptual order.

Nature works, that is, limns and dislimns her structures, by way of changes of every degree of minuteness, which take place in the tissue of material substances consisting of distinct but inseparable elements; both the substances and their elements being objects of perception, either actually perceived or thought of as perceivable. In the last resort, that is to say, when we ask what any material substance is immediately experienced as being, the constituent elements of every species of material substance are of two kinds, formal and material, the formal being the space occupied by feeling perceivable by the sense of touch, or touch with pressure, which feeling is its material co-element. The element of force in any material

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substance which is real in the full sense of real condition corresponds to, and is known by means of, this feeling of touch, or touch with pressure, in immediate experience, or in material substance as immediately experienced, the space element being common to both. Now in neither case, that is, neither in real matter nor in the immediate experience of matter, can these elements formal and material be separated, or thought of as existing separately, from each other. Space and force in real matter, space and feeling in the immediate experience which we have of matter, are inseparable and indispensable elements of the empirically real; and they continue in union throughout all the changes, of whatever kind, which take place in the material substances, and the immediate experiences, of which they are the ultimate elements. Resolve a body into molecules, or a molecule into atoms, or a so-called atom into portions still more minute; still the same two elements, space and force, space and feeling, re-appear in the molecule as in the body, and in the atom, or its constituents, as in the molecule.

But *what* re-appears, it may be asked? Space, force, and feeling, it may be said, are objects of general terms, or conceptions; do these objects, that is, do general terms objectified, reappear in the products of material change; are bodies, molecules, and atoms, composed of Concepts? Not so. We have to speak of them in a way which insensibly leads us to regard them as general terms objectified, or as really existent Concepts, because we have to speak of them in language which, being the creature of conception and thought, is composed of

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general terms; but the objects of conception and thought, and therefore of language also, are percepts; conception, thought, and language, being instrumental to the understanding of perception. It is an illusion, against which we have constantly to guard, to suppose that real existents belonging to the perceptual order, whether they are simple percepts or realities in the full sense, are, like language, the creatures of thought; not to mention that even the general terms of which language is composed have no meaning apart from the perceptual contents, of which they are the generalised expressions. What re-appears in every product of material change is some fully determined mode of space, and some fully determined mode of force, or of feeling, the one occupying the other; which we perceive in their union, and call a single solid thing, —this space filled with this hardness,—not being able to express the perception actually experienced, or thought of as experienced, more closely than by these general terms specialised solely by the demonstrative pronoun *this;* but which is fully determinate in reality, that is, in Nature. This fully determinate union of the two elements it is, which constitutes the body, molecule, atom, or other still smaller constituent if any, an individual or singular in the logical sense, and as such incapable of being exhaustively defined; but nevertheless one of Nature's real existents, belonging at once to the perceptual order, and to the order of real conditioning.

Hence it is, that the universally held fact, that all exact science is measurement, while all measurement is mathematical, not only bases all exact

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science on a mathematical foundation, but also involves the consequence, that all scientific explanations consist of perceptual analysis in the last resort. The real conditions which science seeks are not causes, in the sense of self-existing agents or agencies bringing atoms or molecules of matter together; nor yet causal agencies in the thinking Subject, as with Kant, bringing perceptions together according to *a priori* rules; nor yet a law or force of Negativity, Contradiction, or Contrariety, inherent in the nature of Thought, as with Hegel. They are component parts of the same whole to which the phenomena conditioned by them also belong, and stand in determinate relations to these, as well as to each other.

Whenever, then, we come back to the order of Nature from conceptual analysis, or analysis in which conception has been employed, with its results in hand, and endeavour to realise in thought the actual existence of that order, we have to strike out of the account those conceptions which we have introduced as part of our instrumental method. Matter and force known in their time and space relations are what we retain; the conceptions of genera and species, of possibility, impossibility, necessity, and contingency, of real condition and conditionate, or of cause and effect, are what we dismiss. There are no real conditions in Nature, if by *real condition* we understand a general term objectified; there are but the individual and determinate phenomena in time and space relations, which we group under that conception. The percepts, of which that conception is the short-hand expression, are the real objects.

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To say as so many do, with an imposing air of profundity, that the ultimate nature of real conditioning, or causality as they style it, what it is "in itself," is necessarily unknowable, is to hypostasise or make an entity of our conception, a fictitious entity which is in fact unknowable simply because it is unreal. The reality, I repeat, is in the percepts which are rendered manageable to thought by the conception, not in the reduplication of the conception as a reality. That which is really unknowable in the case, at least by human intelligence, is, not the nature of causality or real conditioning, but what the particular real condition, or set of real conditions, is, in immediate dependence upon which matter and the physical forces which are inherent in it first came into existence.

Thus, the *de facto* is Nature's, the characterisation of it is Man's. These conceptions or characterisations which we employ may be shown indeed to be true, but this involves their being compared to the real, which for this very purpose must be distinguished from them. Or, to state the same thing in terms which have been yielded by our analysis in Book I., all conceptions belong as realities to the world of objective thought, and not to the world of objects thought of, otherwise than as thoughts; *a fortiori* not to that of real conditions. Conceptions of real conditions are not real conditions themselves. Nor do their objects exist in conceptual form, or make part of any conceptual order of real conditioning.

Possibly, however, some one may ask, by what right we attribute reality to percepts while denying it to concepts, both being equally subjective, and

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both alike real in the sense of being objective to reflection? The answer to this question is:— Because to attribute reality in the full sense to everything which is objective to reflection, and solely on that ground, would be to obliterate all distinction between false and true appearance, commonly called the difference between appearance and reality, by bringing all appearances alike, even when incompatible with one another, to the same level of reality or of truth; which would plainly render the very idea of positive knowledge chimerical. The possibility of error begins with the intervention of thought and conception in the stream of perceptual experience; and the sole ultimate test of truth or falsity in thought lies in the comparison of conceptions with the perceptual facts, which they purport to give back in more readily comprehensible shape. If, then, there was no reality in the stream of perceptual experience, of a different kind from that reality which is common to percepts and concepts alike, that is to say, simple objectivity to reflection, there could be no test of truth distinguishing it from error, no characteristic of reality distinguishing it from appearance. The falsity of what is commonly called a false appearance, as, for instance, of a stick being broken when half immersed in water, does not lie in the perceptual part of what we call the appearance, but in the conception which attributes the broken direction to the real stick.

Now one result of the analysis in Book I. was to distinguish the different modes or kinds of reality, that is, the different senses in which the term can be legitimately used; the most important difference

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being that between simple objectivity to reflection and reality in the full sense, the reality met with in real conditions. And this result cannot, I think, be contravened, unless by showing grounds, independent of that analysis, for attributing creative, or at any rate efficient, agency either to consciousness itself, or to some immaterial agent of it, and thus raising either one or the other to the rank of what the analysis calls a real existent in the full sense of the term. But supposing our previous analysis to be correct, this cannot be done without transcending experience, since that analysis purports to be an analysis of experience in its whole range.

Consequently the conclusion of the present Chapter, that concepts are not realities in the full sense of the term, depends upon the correctness of that distinction between two senses of reality which results from the analysis of experience given in Book I. And if that analysis is correct, the conclusion now reached cannot be contravened without transcending experience, by which I mean substituting some unwarranted and *a priori* assumption in place of actual experience, as the basis of the whole theoretical fabric. We have, in fact, no conception at all of an agent or agency, unless and until we have had experience of material objects existing in a world of space. Our notions of reality and agency are drawn from our actual experience of matter, and not our knowledge of the reality of matter from *a priori* conceptions of reality and agency.

CHAPTER II.

THE POSITIVE SCIENCES.

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§ 1. When we pass to the other side of the line of demarcation spoken of in § 9 of the foregoing Chapter, that is to say, to the relation between Newton's *vis inertiæ* and *vis impressa*, we find that we are *ipso facto* considering the relations of different portions of matter *inter se*, and that these relations, so far as they are relations of force at all, are all of them kinds or modes of *vis impressa*, are actions and re-actions of *vires impressæ* on each other, or rather on the separate portions of matter in which they reside as modes of motion or tendency to motion.

Now this passage to the other side of the line, that is, to *vires impressæ* exerted by separate physical substances, is a most important turning point in scientific method. It marks the transition from considering the nature of Matter to the consideration of the events in its history, as composing an order of real conditioning. When we think of Matter simply in its nature, we think of it as essentially involving space and force, which together constitute its nature as a real occupant of space, or real existent in the fullest sense of the term, and which give to the whole or any part of it

both volume and mass. But in so thinking of it we are abstracting entirely from the historical order of its existence, and consequently from the question of the character of its initial state, as for instance, whether it comes into existence single and continuous, or broken up into separate portions; whether homogeneous, or in many specifically different kinds; and therefore also from the question, whether it is originally in a state of rest or of motion; neither affirming nor denying, but simply abstracting from, these and similar alternatives. BOOK II. CH. II. § 1. Dynamic.

But when we proceed to consider it as broken up into separate portions exerting *vires impressæ* on each other, the question of initial state at once confronts us, and with that question we enter upon the consideration of Matter in its historical order as an order of real conditioning. We then enter for the first time upon Positive Physical Science, inasmuch as we have then the actual historical order, or Course of Nature, before us. Not that we begin by attempting the question of the nature of its initial state, or that of the epoch in absolute time when its first genesis took place, or that of the possibility of some form or forms of it being originated *de novo* from time to time, out of what we conceive to be its real conditions, positively unknowable to ourselves, at any epoch or epochs from the genesis of the first form of it to the present day, or again from the present day onwards into the as yet non-existent future. Far from it. These are not questions to be lightly approached. We have first to make a selection of some class or classes of phenomena, with which

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our enquiry shall begin, and then of some point in the history of the phenomena selected, that is, of some definite event or occurrence in them, which we can begin by examining. It is thus not the nature of Matter or Force simply, but the nature of events or occurrences in their history, that we are then investigating;—that is to say, the nature of their actions or operations, which is described or defined by the general laws to which they are said to be subject, but which are strictly uniformities which they display, wherever and whenever in the single course of mundane history they or their similars may occur or be repeated. On this previous analytic inquiry into the nature of the operations of matter depends all possibility of ever ascertaining the single course of its actual history, to say nothing of the nature of its initial state, or that of any part or parts of it, which may be or may have been subsequently originated *de novo*, and not out of pre-existing matter.

Now the simplest form which Positive Physical Science can take has been found to be that in which it deals with the relations and interactions of masses of ponderable matter, that is, matter subject to the Law of Gravitation, taken as homogeneous, but of all degrees of magnitude; and that in three departments, severally devoted to the three states in which ponderable matter is found to be capable of existing, namely, the solid, the liquid, and the gaseous.

In selecting this province with its three departments as the first province of physical science, we are abstracting in the first place from all those intrinsic relations and interactions of masses of

ponderable matter, upon which the specific properties of different kinds of material substances depend, so constituting them specifically different substances; and from their affinities with each other, and the laws governing their composition and decomposition; as well as from the question whether specific differences of nature are or are not to be found in the ultimate minima of which they are composed; all which considerations belong to the domain of Chemistry.

Secondly we are abstracting from the phenomena of life, and the vital energies in which life consists, which are phenomena and energies manifested in organic substances; since these substances must at any rate be chemical compounds, depending on chemical affinities and reactions.

And thirdly we are abstracting from those modes of force or energy which seem to demand the hypothesis of some etherial, that is to say, some material but imponderable medium, or media, as their vehicle, such as are the energies subserving the transmission of light and radiant heat, and the phenomena of electricity and electromagnetism.

The province of physical science, so distinguished as the first, is Dynamic; and this has two main subdivisions, which, in that department of it which deals with solid matter, are known as Kinetic and Static.[1] To these subdivisions of the first department correspond those of Hydrodynamic and Hydrostatic in the one, and those of Aerodynamic and Aerostatic in the other (called also

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[1] See for the use of these terms, in place of Mechanic, &c., a *Treatise on Natural Philosophy*. By Sir W. Thomson (Lord Kelvin) and Professor P. G. Tait. Vol. I. Preface, p. vi. Edition of 1879.

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Pneumatic), of the two remaining departments. It is in the first department of this first province of physical science, that the ultimate nature of energy and the ultimate forms in which it operates can be best realised in thought, partly because of the abstract simplicity of the relations studied, and partly because of their greater accessibility to observation and experiment.

With respect to this position at the head of the more concrete physical sciences universally accorded to Dynamic, a few more words must be said. We have seen in the foregoing Chapter, that Force is *the doing* essential to, and contributing to constitute, Matter, so that without it Matter would not exist; while the other essential constituent of Matter is some portion or portions of three-dimensional space, which force exclusively and adversely occupies. Or again, Matter is active and adverse occupancy of space, and exists by so occupying it. This conception avoids the inconvenience of taking Force as hypostasised *per se*, which is done, or at any rate not precluded, when it is described, in the most usual way, as "any cause which produces or tends to produce a change in a body's state of rest or motion;"[2] whereby "body" also, that is, some mass or portion of matter, is similarly and necessarily hypostasised apart from force.

But in the present conception of matter as composed of force and the space occupied by it, the distinction between differences of quality and differences of quantity is implicitly contained. Differences in the quality of matter are differences

[2] Chambers' Encyclopædia. Article *Force*. Vol. IV. Edition of 1862.

in the mode of its space-occupancy, that is, are so many different kinds of physical force. The various kinds of physical force empirically experienced, the so-called Forces of Nature, dynamical, molecular, chemical, electric, magnetic, vital, must then be conceived as the doing or action of so many different modes of the configuration or space-occupancy belonging to matter, and belonging to it throughout, down to its minutest particles. Differences in the properties displayed by different kinds of matter must ultimately be referable to differences in the quality of its ultimate particles, that is to say, to differences in the modes of force which severally constitute them space-occupants. But differences in the modes by which ultimate particles are space-occupants must also be differences in the minute configuration of the spaces occupied, that is, differences either of volume, or figure, or density. So that, conversely, every specifically different mode of configuration, down to that of the minutest particles, has a specifically different mode of motion or tendency to motion, as its doing or action, that is, as its inherent force. And it is probably in consequence of this inseparability, I mean the inseparability of configuration from space when occupied by force, that the specifically different energies of specifically different matters or forces are capable of correlation, that is, are transformable within certain limits into one another, the total amount both of energy and of mass being conserved.

Here, it will be noticed, the conception of configuration of matter becomes the basis of the conception of its having different kinds, qualities, or

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modes of action; that is to say, without the conception of configuration in space,—irrespective of the question, whether differences of configuration can or cannot be ascribed to strictly ultimate particles,—no differences of kind or quality of matter or of force would be positively conceivable. But configuration of matter is a simply spatial conception. And in order to conceive changes in its configuration, we need only add the conceptions of time and motion. These are the root conceptions of all positive science; and give rise to purely quantitative measurements of physical phenomena, so soon as, abstracting from qualitative differences in the mode of their space occupancy, we consider any particular class of physical phenomena as homogeneous. Every single kind of active matter, or force, has its own laws founded on its own specific configuration, laws expressing the action of the physical phenomena which belong to it, and which are homogeneous *inter se.* In other words, each has its own quantitative basis.

The mechanical stresses exhibited in the action of bodies on each other, abstracting from differences in the molecular configuration of those bodies, and therefore from the different forces in which the stresses themselves may originate, may be said to be the special object-matter of Dynamic, in both its divisions, kinetic and static. The phenomena of dynamic are in this way reduced to a certain homogeneity, and rendered capable of a purely quantitative treatment. Time, space, volume, mass, force, motion, velocity, momentum, energy, are all taken as *quanta.* Variations in one depend on variations in others. And the definition of any one

of them as a quantity can only be given by reference to the definition of others, to which it is proportional, or by which it is measurable. Thus the mass, or quantity of matter, of any body is proportional, we are told, "to the volume and density conjointly"; where by *density*, I apprehend, must be understood the matter or force itself, which is the subject of measurement, and is not measurable otherwise than by first taking a certain volume of it to measure, volume being a purely spatial determination, and directly measurable. And again, "the measure of a force is the quantity of motion which it produces per unit of time."[3] Units of measurement, taken in time and space, by means of differences in their content, are thus the foundation of the whole system.

Returning now to the conception of an aggregate of homogeneous bodies exerting *vis impressa* on each other, we find in the next place, that it involves the presence of Motion on the part of these bodies *ab initio*. Or in other words, that it is impossible to conceive such an aggregate to have existed for any period of time, however brief, without motion arising, or rather existing, between its parts. There never can have been a time during which such an aggregate was in a state of unbroken rest. For we must either consider the homogeneous aggregate as implicitly representing the whole world of matter, or else as one aggregate in presence of others heterogeneous to itself. And in the former case, to account for motion arising in it, subsequently to a supposed initial state of

[3] The *Treatise, etc.*, above cited. Vol. I., Chap. II., Sections 208 and 220 (pp. 220 and 224).

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unbroken rest, would involve hypostasising some abstract entity as an agency extraneous to it as matter, a proceeding already shown to be illegitimate; while in the latter case, to suppose its motion due to some other aggregate or aggregates is *eo ipso* to suppose its motion coeval with the presence of those aggregates from which it is received. Thus neither any hypostasised agency, nor force in the sense of *vis impressa*, can be the original setter up of motion in matter, or prior to it in the order of real conditioning. But, as already shown, that same force, which when conceived as *vis insita* is conceived as an activity contributing to constitute matter, we conceive again as *vis impressa* exerted by one particle of matter upon another,—in which action motion is necessarily involved,—the moment we conceive matter as already constituted, and forming an aggregate of homogeneous particles.

Motion, therefore, in physical bodies must be conceived as nothing else than that kind of change which is proper to them simply as occupants of space, that is, which is time-change and space-change together, just as the changes in the time-stream of consciousness as an existent are change in time only. Motion in matter corresponds to change in consciousness, in respect of their both being universal, and both primeval, that is, coeval with that to which they respectively belong. In the case of neither can a real beginning of them, or initial state prior to them, be construed to thought; no initial state, either of consciousness or of matter, can be positively conceived, into which we are not compelled to read back, from our empirical

experience, change in the one case, motion in the other, as necessarily involved in them. An initial state of either, conceived without that ingredient, is conceived only by abstraction.

A similar result meets us when we come to the question of the logical priority between the two states of motion and rest, in the province of Dynamic. The question of logical priority between them, I mean as to which of them is pre-supposed by the other, in construing to thought any state of aggregation taken as an initial state, seems to depend on the phenomenon of equilibrium. Now equilibrium which is rest, or null motion, can be construed to thought as resulting from bodies tending to move in opposite directions with equal energies, and being in contact with each other. That is to say, given motion and you can understand rest. On the other hand, given rest and you are wholly at a loss to understand motion. It is in this way that we also have to think of the consistence, or coherence *ad intra*, of any minimum of matter, namely, as a tendency to move towards one another existing in what we must conceive as its parts, though not parts which are separately material; a necessity of thought which arises, as already noted, from the space which it occupies being infinitely divisible. Thus even the nature of matter can be conceived only by reading back into it, as a pure or abstract tendency to motion, what in actual experience we find as a result of real but interrupted motion. In this way motion is also the logical, but not the real, *prius* of Force, (as well as of rest), considered as one of the essential constituents of the nature of matter. For motion is

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the logical *prius* of tendency to motion, and tendency to motion is the only way we have of construing the nature either of force or of matter to thought, in combination with space, the other essential constituent of matter.

Now it is only when in thought we start from the conception of matter being at rest, that we have any need to introduce the idea of force as the cause of motion arising in it. Assume motion as coeval with any concrete form of matter, as for instance the form of homogeneous aggregation which is the object-matter of Dynamic, and you thereby, *eo ipso*, conceive force as either motion or tendency to motion in the bodies composing the aggregate. The *vis insita* of the nature of matter becomes the *vis impressa* of the order of real conditioning, by and in the motions of the bodies of the aggregate relatively to each other. *Vis insita* is as it were drawn out into *vis impressa* in the form of motions and tendencies to move, whether repressed or promoted, on the part of the separate bodies between which, and only between which, *vis impressa* exists. In this way it seems most true to say, that motion is not caused by but IS force, whenever force is conceived as *vis impressa*, that is, as existing between separate bodies.[4]

(4) In speaking as above of *vis insita* being 'drawn out' into *vis impressa*, it may be worth while to remark, that the expression implies a mode of thinking which is founded in the ultimate nature both of consciousness and of real existence in the full sense, as objectified in consciousness. It meets us everywhere in philosophical writing, as for instance in Philo,—*Τέμνεται γὰρ οὐδὲν τοῦ θείου κατ' ἀπάρτησιν, ἀλλὰ μόνον 'εκτείνεται. Quod deterius potiori* &c. Philonis Judæi Opera. Ed. Mangey, page 209). The explanation and the justification of it alike are found in the formal element of all experience, time, which is the continuation of the content of the consciousness of one moment into the next and subsequent moments, as shown by the analysis of Book I. When the object which we are experiencing is, or is thought of as, a material object, then the properties which it has at any moment, that is, at any real or ideal section of its existence, taken transversely to its time-sequence or duration, are or may be continued into the next and

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Some light seems also to be thrown by this way of apprehending the subject upon the much controverted conception of *actio in distans.* For if we deal with matter as an aggregate of separate portions of matter at rest or in motion relatively to each other, then, wherever we suppose separation, we also *eo ipso* suppose an interval or distance however small. And then the conception of *actio in distans, i.e.,* action upon a distant body, in the most comprehensive sense of the term, becomes a necessity, since all action between separates is then conceived as action between *distantia,* even in the case where particles of ponderable matter are thought of as immersed in an otherwise continuous medium. For there is always some distance, however small, between the continuum and the particles immersed in it, as well as between the particles themselves. The difference between what is called contact action and action at or through a distance, as commonly understood, then becomes merely a difference of degree from the purely analytical point of view. The latter, which we may call conspicuous *actio in distans,* as displayed apparently at least in

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subsequent moments; that is, figuratively speaking, are 'drawn out' into a process, from the moment at which the transverse section has been taken. It is in this sense that *vis insita,* which is everywhere and always inherent in matter, as one of its essential constituents, is everywhere and always to be thought of as being continued in the processes involved in its exertion as *vis impressa.*

It is thus that subjective analysis throws light upon turns of thought and habits of thinking which, necessary as in some cases they are, and where not necessary may often be useful, are yet peculiarly liable to misinterpretation, and easily mislead those who make use of them. The one now signalised is as insidious in this respect, when not thoroughly understood, as the use of abstract general terms is, in leading us to assume the existence of individual realities corresponding to the terms, in addition to the particular perceptions which they gather up and throw into conceptual form. In the present case, the *vis impressa* and the *vis insita,* which is said to be 'drawn out' into it, are not two things, but one thing described first by a term of *nature* and then by a term of *genesis,* on the supposition of there being a plurality of substances in presence of one another, each possessing the thing described as an essential attribute of it. Yet, though a single thing only is intended, there is no hypostasising implied of *vis,* or force, *per se,* as a separable *nexus* linking material substances together.

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gravitation, or in the attractions and repulsions between magnets, becomes then susceptible of two interpretations or explanations ; it may be taken either as real action at a distance, at distances which are sensibly appreciable, or else as due to other real actions at a distance, such as pressure and rebound between a continuous elastic medium and ponderable particles immersed in it, which are cases where the distances are real but not sensibly appreciable. The latter mode of explanation in many cases, as for instance in that of gravitation, would involve the hypothesis of the presence of some medium of intercommunication, or transmission of force, not itself presentatively perceptible by human senses.

All action between separate bodies, then, being really *actio in distans*, the question is, how such action can be rendered conceivable. The difficulty in conceiving it arises, as it seems to me, from attempting to bring it under the common-sense conception of force which we derive from cases of contact action, cases which can afford us no real aid in conceiving it, since they are themselves in reality instances of *actio in distans*, instances, that is, of the very thing which we are attempting to conceive by means of them. It must be a higher or more general conception under which *actio in distans* must be brought, if the difficulty in conceiving it is to vanish. Such a higher conception seems to be offered by the idea of a configuration, or system, of material bodies in space, which are in motion, relatively to one another, and whose relative motions depend on the relative positions which they occupy in the system, from moment to moment. The force

exerted, which we call the action and reaction of one body on another, is force belonging to the system as a whole, though distributed among the bodies composing it in proportion to their mass. There is no emission of force or energy from one body, no influx of force or energy into another. Their movements relatively to one another, which are changes in the configuration of the whole system, according to uniform laws, and in consequence of the activity inherent in every body or part of the system, though separate in space one from another, are really that which we call their action and re-action upon one another, and which we may seek in vain to render intelligible by analogy with such unanalysed experiences as those of pushing and pulling. It is, however, in the form of action and re-action that these movements are treated in dynamic.

The subject before us, then, is *vis impressa*, and this in its lowest terms may be considered as the action and re-action taking place between two bodies only. Here I must have recourse to quotation from authorities.

"The mutual action between two portions of matter," says Clerk Maxwell, "receives different names according to the aspect under which it is studied, and this aspect depends on the extent of the material system which forms the subject of our attention.

"If we take into account the whole phenomenon of the action between two portions of matter, we call it Stress. This stress, according to the mode in which it acts, may be described as Attraction, Repulsion, Tension, Pressure, Shearing stress,

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Torsion, &c."[5] In speaking of stress, however, care must be taken not to confuse it with strain. By strain is meant a change of size or shape in a body, excluding the consideration of the force producing the change. It is the force producing a strain which is called stress.[6]

Vis impressa, then, is always exhibited in some form of stress, which in its lowest form is a stress between two bodies making a single system, one of which bodies is said to act, and the other to re-act, on the other, whereby an alteration of their states of rest or motion is effected. Impressed force considered with reference to this effect is completely defined and described in Newton's three Axioms or Laws of Motion. These Laws are as follows:

First Law of Motion: "Every body perseveres in its state of rest or of moving uniformly in a straight line, except in so far as it is made to change that state by external forces."

Second Law of Motion: "Change of motion is proportional to the impressed force, and takes place in the direction in which the force is impressed."

Third Law of Motion: "Re-action is always equal and opposite to action, that is to say, the actions of two bodies upon each other are always equal and in opposite directions."[7]

We now see what is meant by *vis impressa* or Stress, and this covers the whole ground of what may be described as the first step in Dynamic. But

[5] *Matter and Motion.* By J. Clerk Maxwell, F.R.S., in Manuals of Elementary Science, published by the S.P.C.K. 1876, Article XXXVII. See also Art. LV.: "*Action and Re-action are the partial aspects of a stress.*" It will be seen how greatly I am indebted to this well-known Manual in the resent Chapter.

[6] *Ibidem.* Art. LXXXIII.

[7] *Ibidem.* Art. XXXVIII., XL., XLI., XLIV., LIV.

we are still far from coming into sight of the concrete course of operations, dependent on the continued action and interchange of stresses, which constitute that contribution to the whole Course of Nature, or Order of Real Conditioning in its entirety, which it belongs to Dynamic to investigate. We have reached as it were the first halting place in our subject, namely, the nature and laws of *vires impressæ*, or stresses of various kinds. We have next to see how these forces are continued and combined into definite processes, forming as it were operations of definite length in the concrete history of matter, considered as an aggregate of separate but homogeneous portions. Such operations may be described as changes from one configuration of matter at the beginning, to another configuration of it at the end, of the processes in question. The next step, then, briefly described, is to give the rationale of the passage from Stress, or *vis impressa*, to Energy Potential and Kinetic,—Energy being defined as "the capacity of doing Work." and Work as "the act of producing a change of configuration in a system in opposition to a force which resists that change."[8]

The origin of the conception of Energy is found, historically speaking, in Leibniz' conception of *vis viva*, who defined what he called the *vis viva* of any moving body by the product of its mass into the square of its velocity (mv^2). But the passage, as I have called it, from the conception of force to that of energy, that is, the connection between the two conceptions, was given by Newton, when in a

[8] *Ibidem.* Art. LXXII.

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certain statement (presently to be quoted) in his Scholium to the Laws of Motion he "estimates action and re-action by the product of a force into the velocity of its point of application," instead of considering them merely as the opposite aspects of a stress. "According to this definition the action of the external agent is the rate at which it does work." (*Ibidem*, Art. XCVI.).

"Newton," says Clerk Maxwell in the Article from which I have taken the whole substance of the foregoing paragraph, "Newton, in the 'Scholium to the Laws of Motion,' expresses the relation between the rate at which work is done by the external agent, and the rate at which it is given out, stored up, or transformed by any machine or other material system, in the following statement, which he makes in order to show the wide extent of the application of the Third Law of Motion:

'If the action of the external agent is estimated by the product of its force into its velocity, and the re-action of the resistance in the same way by the product of the velocity of each part of the system into the resisting force arising from friction, cohesion, weight, and acceleration, the action and re-action will be equal to each other, whatever be the nature and motion of the system.'

That this statement of Newton's implicitly contains nearly the whole doctrine of energy was first pointed out by Thomson and Tait."[9] (*Ibidem*, Art. XCVI.)

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[9] See their work *Treatise of Natural Philosophy* already cited. Sections 261 to 264. Vol. I., pp. 246 to 248. Edition 1879.

The connection between the two conceptions of force (*vis impressa*) and energy seems, then, to lie in the conception of rate of action, that is, the rate at which a change is effected in the configuration of a system of bodies by a force external to it,—the idea of *rate* being introduced by that of velocity, which is rate of motion (distance of space traversed in unit of time), and the action of the external force operating, and that of the parts of the given system resisting, being estimated in the same way, namely, as the product of their force into their velocity. In taking account of the resistance we bring rate of work before us, instead of simply rate of motion. And we pass from the conception of action and re-action to that of energy doing work, when we introduce the notion of definite changes of configuration in a system of bodies being effected in definite time-durations, and consider that system as the seat of resistances, or forces resisting a change, which a force acting on it externally is operating to produce. "Work done by an external agent on a material system may be described as a change in the configuration of the system taking place under the action of an external force tending to produce that change." (*Matter and Motion*, as above. Art. LXXV.)

Briefly, then, we may describe Energy (without for the present taking account of the distinction between potential and kinetic), as the continued efficiency of an operation, in which *vis insita*, *vis inertiæ*, and *vis impressa* are all combined; or again as the continuous efficiency of *vires impressæ* in interaction, estimated by the effects or changes produced in the configuration of the whole material

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system concerned, from the beginning to the end of any process or operation selected, instead of being defined by an analysis of the forces which combine to constitute it.

We may now consider the difference between those two forms or rather modes of energy, mutually involving one another, into which all energy may de divided, or rather of which it may be said to consist, namely, Kinetic and Potential Energy. We may perhaps look at it in the following manner. Every portion of matter, and every material system consisting of such portions, must be either in a state of motion, or in a state of null motion, rest, or equilibrium. And as energy, defined as the capacity which matter has of doing work, is evidenced by nothing but a change from one state of rest to another, whether such states of rest are actually observable in empirical existence, or are hypothetically introduced into it by ideally arresting its course at a given moment, it follows that energy must be held capable of existing in two and only two modes, namely, energy of motion and energy of position and configuration, all cases of null motion being clearly cases included under the latter term. Energy of the former kind, that is, of motion, is called Kinetic, energy of the latter kind, that is, of configuration, is called Potential Energy.

These two modes of energy would accordingly seem to be nothing else than the forms taken by our old friends *vis impressa* and *vis inertiæ*, imagined as seated in different bodies or systems of bodies, and producing different effects in different periods of time. Potential energy may be regarded as the

vis inertiæ of a body or system of bodies, which we saw became *vis impressa* when called out into re-action; and Kinetic energy as the *vis impressa* of a body or system of bodies, exerted upon and calling out the re-action of another. "The energy which a body has in virtue of its motion is called kinetic energy.—A system may also have energy in virtue of its configuration, if the forces of the system are such that the system will do work against external resistance, while it passes into another configuration. This energy is called Potential Energy. . . The different forms in which energy has been found to exist in material systems have been placed in one or other of these two classes—Kinetic Energy, due to motion, and Potential Energy, due to configuration." (*Ibidem.* Art. XCVII.)

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Matter in the one mode is an expender, in the other a storer or, it may be, a dissipator of energy. It is the almost infinite capacity for change in the relative position of its bodies, and of the particles composing material substances, which enables matter to act now as storing, now as expending, energy. It stores it as potential energy in the form of tensions or pressures, partly between the particles composing a body, which alter or tend to alter its internal configuration, and partly between it and contiguous bodies, without producing motion of the body as a whole. It expends it as kinetic energy or energy due to the motion of a body in which potential energy has been stored. And both processes, storage and expenditure alike, are processes of action and re-action of separate bodies or parts of bodies one upon another. "There are . . . many

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different modes in which a material system may possess energy, and it may be doubtful in some cases whether the energy is of the kinetic or the potential form. The nature of energy, however, is the same in whatever form it may be found. The quantity of energy can always be expressed as that of a body of a definite mass moving with a definite velocity. (*Ibidem.* Concluding paragraph of Art. XCVII.)

Moreover, since in all cases what matter expends in the one mode it acquires in the other, the change from the one to the other going on at every moment of the processes in question, it follows that neither gain nor loss of the energy of matter on the whole ever takes place; provided we consider the material world as including within itself all the energies of every kind by which work can be done, and provided also, that the work so to be done does not bring about a state of the material world in which the almost infinite capacity for change spoken of above is itself exhausted or destroyed.[10] This is the foundation of the principle or doctrine known as the Conservation of Energy, of which I take from Clerk Maxwell the following general statement:

"The total energy of any material system is a quantity which can neither be increased nor diminished by any action between the parts of the system, though it may be transformed into any

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[10] These words are an allusion to the tendency insisted on by Lord Kelvin, which may be described (in Rankine's words) as "the tendency which exists in nature to the dissipation or indefinite diffusion of mechanical energy originally collected in stores of power."—See also the opposite possibility admirably stated in a paper by Rankine, "On the Reconcentration of the Mechanical Energy of the Universe," now to be found in his *Miscellaneous Scientific Papers*, p. 200.

of the forms of which energy is susceptible." (*Ibidem*. Art. LXXIV.)

What the other forms are, into which dynamic energy may be transformed, will be considered in the following Section, in dealing with the Correlation of Energies. The doctrine of Conservation of Energy in Dynamic relates only to the distinction between the potential and kinetic modes of one kind of energy; but this distinction is also found in all kinds of energy whatever.

The expansion of a simple instance, in reliance on Clerk Maxwell (See Art. LXXV. and XCVII.), may serve to make clear to non-experts (like the present writer) the change from potential to kinetic energy in doing mechanical work. Suppose a stone lifted by the hand to a given height above the ground and placed upon a shelf. This upward displacement of the stone is work done by expending some of the energy stored in the man's organism, where it exists as potential energy, the expenditure taking place as, or in the form of, kinetic energy, the energy of the hand when moving, after grasping the stone. It is mechanical work done by the moving hand against the resistance of gravitation, and reappears as potential energy, or energy of configuration, in the system of bodies acted on, namely, the earth and the stone; the same quantity of potential energy which is expended by the hand re-appearing as potential energy acquired by the stone in its new position with regard to the earth. Thus the work done, that is, the upward displacement of the stone, measures the kinetic energy employed in effecting it, the force of gravitation, against which it is

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effected, being in the form of potential energy due to the configuration of the system, namely, the position of the weight on the ground previous to its being lifted.

And since the change of form, from action and re-action, as in stress, to energy potential and kinetic, makes no difference with regard to the law that action and re-action are always equal and opposite, it follows that the kinetic energy may be considered either as one half the total energy displayed in the whole action under discussion, or as the *vis viva* of the moving hand *minus* the resistance which it overcomes; and kinetic energy is accordingly expressed as one half the *vis viva* ($\frac{1}{2}mv^2$), the other half being set down as potential energy, or resistance due to configuration.

For further elucidation, let us now consider the sequel of the phenomenon instanced, the return journey of the stone to the ground, supposing the shelf on which it has been placed to be suddenly removed. The stone instantly begins to move, *i.e.*, becomes the seat of kinetic energy under the influence of gravitation, just as before it became the seat of kinetic energy under the action of the hand lifting it. The stone now falls, expending a certain small amount of its acquired kinetic energy in altering the configuration of the air which it traverses (which is a case of dissipation of energy so far as any useful purpose is concerned), and expends the remainder of it in altering its own configuration and that of the ground (as, *e.g.*, by driving a nail farther into a floor), upon which it falls with a certain velocity. The quantity of energy, which was part of that originally stored in

the organism, the stone, and the earth, and which was expended in the form of kinetic energy in lifting the stone and placing it on the shelf, became potential energy in the stone and the earth while the stone was on the shelf, was then changed into kinetic energy during the fall of the stone, and finally became potential energy again, in giving the new configuration to the air, the stone, and the earth, when it comes again to rest upon the ground.

From this we see on the whole, that, at every moment of each of the two kinetic processes, the upward lift and the downward fall, kinetic energy is being at once produced out of potential in one momentary configuration, and changed into potential in another momentary configuration. The essence of energy as a process consists in this change of kinetic into potential, and potential into kinetic energy, which takes place continuously in all cases of motion (the momentary configurations being only ideally discernible); just as the essence of stress consists in the action and re-action of *vires impressæ*. At every instant of the motion, potential energy is being both stored and expended, and kinetic energy the same, the disappearance of energy in one form being *eo ipso* its appearance in the other; the motion itself being the process which mediates this four-in-one change, the process in and as which the change takes place. This we see when we look at energy merely as a process, abstracting from any empirically observable or demonstrable termini *a quo* and *ad quem*. In this abstraction we then see nothing but the change of one mode of energy into the other and *vice versâ* (by means of ideally introduced moments of arrest

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at some ideally introduced configurations); and this change is the essence of energy as a process.

But when, returning from this abstraction, we re-introduce its termini into the process, as its beginning and its end, no matter where they may be taken, or at what interval of time from each other, provided they are really demonstrable in the concrete process, then that character of energy by which it is capable of storage and expenditure immediately makes its appearance, and we find ourselves considering the termini as configurations in which potential energy is stored, and the process between them as the flowing of that stored energy from one configuration to another, that is, as kinetic energy.

Now it is the second and more concrete way of apprehending the subject which is most prominent in sciences more special than Dynamic, as well as in the practical applications of all. The chief practical question is something of this kind—How much energy a given material substance or structure, either organic or inorganic, can exert, how much work it can do, before its store of energy is exhausted. But it would be a great mistake to argue from this, that energy must be regarded, like Matter, as itself a concrete or empirically real object, that is, a real condition. Energy, we have seen, represents force, stress, *vis impressa;* or is force in another shape, or considered in a different manner; and force is but one of the two constituents essential to the nature and existence of real and concrete Matter. Energy involves configuration of matter in space, just as force involves the portion of space which it occupies, or the occupa-

tion of which by force constitutes a portion of matter. Potential and kinetic energy, therefore, cannot be taken as real by themselves, that is, as abstractions and yet real in the full sense, any more than force can; nor are they in any way construable to thought, except as modes or forms in which real and concrete matter (in which the force which they represent is an essential constituent) exists and operates.

Taking a glance in retrospect over the foregoing brief statement of the main purpose of Dynamic, we see that the order of ideas under which it has been exhibited is complete and unbroken. Beginning with Newton's *vis insita*, as one of the two inseparable constituents of Matter, we pass in the second place to the consideration of the order of its real conditioning, which we do when we advert to the separation of its empirical parts, and to their motion, thereby entering upon the domain of Dynamic. Here *vis insita* appears in the form of *vis inertiæ*, upon which *vis impressa* is exerted, and which itself takes the form of *vis impressa*, in re-action upon it;—the two together constituting Stress in various forms. Thirdly, adverting to the fact of change from a former to a latter state of matter, which is a change depending upon stress, we have the phenomena thereby classed as phenomena of Energy. Between these two classes of phenomena, of stress and of energy, there is a close analogy. Energy of motion corresponds to the action of a *vis impressa*, which is taken as the originating action in a stress; and energy of configuration corresponds to what we call the re-action upon it, which in the simplest case may be

regarded as the exertion of a *vis inertiæ*. Both forms of energy are equally essential to its existence as energy.

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§ 2. Physical energies are those modes of force which lie nearest to us, the πρότερον πρὸς ἡμᾶς, in the sense of being the modes in which the force inherent in external real conditions immediately act upon and in our organs of sense and thought, so as to determine states of consciousness to arise in them. Living organisms equally with inorganic substances are the seat of energies, by which they communicate with, *i.e.*, act upon and are acted on by, other substances and other organisms; and by which, it may be added, different parts of the same organism communicate with each other. Energies proceeding to an organism capable of sensation, from bodies or other physical media, are the means by which that organism becomes aware of the nature and presence of the bodies and media by which it is surrounded; and energies proceeding from that organism are the means whereby it re-acts upon the bodies and media surrounding it. Before a body external to our organism can produce in us a sense of touch or pressure, of light or colour, of sound, of heat or cold, and so on, a certain change in the states of energy in that body, or in the media through which its energies are transmitted, and in our organism relatively to one another must take place; and on that change occurring, with the requisite degree of difference between the states involved in it, a sensation in some way corresponding to it results. Perceptions thus arising are the only source of our coming to know anything whatever, either of the existence or

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of the properties, of the material and external world. For this reason the organism may be called the proximate real condition, and bodies and media external to it the remote real conditions, of the arising of those perceptions.

From this it by no means follows, that the different physical energies in Nature correspond severally to the several modes of sensibility with which our organisms are endowed, any more than it follows from the fact of our objective thought of matter being composed of visual and tactual perceptions, including sense of effort, that real matter, that is, matter thought of and operative as real condition, is composed of those perceptions, and not of force occupying space, as we have seen it is. Physical energies in Nature are specifically different operations of physical matter, that is, of matter apprehended as the total aggregate of positively knowable real conditions. At the same time we undoubtedly possess a means both of increasing our knowledge of the physical energies already known to us, and of discovering others as yet unknown, in the states of consciousness which are their conditionates. From new experiences new inferences may be drawn; which is in fact, nothing but a continuation and conscious application of that very mode of interrogating experience by which our knowledge of a physical world of real conditions has originally been acquired.

The first question to meet us is therefore this,—What are the ultimate specifically different kinds of energy in Nature at present known to us, besides that which is the object-matter of Dynamic, namely, energy arising from stress between bodies

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treated as separate but homogeneous? Or we may put the same question in a more general shape by asking,—Are there any energies in the material world, when we look at it unsubjected to the restriction of taking it as an aggregate of separate but homogeneous bodies? In both cases, of course, we mean by an energy an operation consisting of an alternation between two inseparable modes, the names of which in Dynamic are potential and kinetic. The priority of Dynamic, or its position at the head of the physical sciences, rests on its ascertaining and demonstrating the fact and the nature of energy with its two modes potential and kinetic, which, as it subsequently turns out, is that most general fact, under which all the operations studied in the remaining sciences must be brought as special cases, in order to be scientifically and thoroughly explained.

And in fact it appears, that the phenomena of all these sciences, including physiology (the sciences being taken as independently and analytically established), may be severally grouped as forming so many different branches of one comprehensive science, the foundations of which are laid in Dynamic, and in which, when once established, Dynamic is itself included, namely, the science of Energetic. "The doctrine of Energy—of its 'Conservation,' and the 'Correlation' of its several kinds—is one that binds together all the Physical and Physiological Sciences, by showing that a principle pervades them all, which is strictly analogous, if not identical, with a long-known Proposition in Dynamics."[1]

[1] *An Elementary Exposition of the Doctrine of Energy*, by D. D. Heath, 1874, Preface, Page VI.

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Let us see, then, in the first place, what ways of treating the material world come into view, when we remove the restrictions which serve to demarcate Dynamic, by confining it to deal (1) with homogeneous, (2) with separate portions of ponderable matter. Now we can never entirely get rid of homogeneity in ponderable matter. But we can conceive it as composed of practically least or ultimate particles, grouped into aggregates which are homogeneous within themselves, but heterogeneous from other aggregates and from the particles composing them; a view which at once gives rise to the further questions, whether in analysing any homogeneous aggregate we can ever come to real minima or atoms of matter in the strict sense, and if we can, then whether the ultimate atoms of all substances are as such homogeneous, or are reducible only to a certain number of classes, heterogeneous to each other. In so treating matter, we are considering its intrinsic differences of structure and composition, both ultimate and derivative, and the branch of science which so treats it is Chemistry.

Secondly, we may remove the restriction of separateness, whereby we return again to the supposition of homogeneity in the matter treated of; but in so doing we find nothing which at once answers to our conception of a continuous and homogeneous matter and is also presentable to the senses, and subject to the law of gravitation. There may be, and in fact there are, the very strongest reasons for assuming hypothetically the real existence of a matter of the kind required, namely, continuous, homogeneous, imponderable,

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and not directly presentable to sense; and that notwithstanding that no definite and self-consistent conception of it, compatible with all the facts which seem to render its assumption necessary, has hitherto been framed, or perhaps I should say, has met with general acceptance. This practically continuous and homogeneous matter is conceived as filling up not only the interstices between the ultimate chemically known or knowable particles, or atoms, of physical substances, but also the interstellar spaces, and possibly also extending indefinitely into space, beyond all existing visible and tangible bodies. This hypothetically assumed matter is known by the name of the Ether. It is called in chiefly in order to render intelligible and calculable the phenomena of Light, Radiant Heat, Electricity, and Magnetism. Whether Gravitation, which is what I have called above a "conspicuous" *actio in distans*, is or is not in some way referable to etherial action, is still an undecided question, as it was in Newton's time, and as it was recognised to be by Newton himself.

Ethers in great variety, we are told on high authority, were at one time in the history of science devised, in order to account for various classes of phenomena. But of these "the only æther which has survived is that which was invented by Huygens to explain the propagation of light. The evidence for the existence of the luminiferous æther has accumulated as additional phenomena of light and other radiations have been discovered; and the properties of this medium, as deduced from the phenomena of light, have been found to be precisely those required to explain electro-

magnetic phenomena. * * * Whatever difficulties we may have in forming a consistent idea of the constitution of the æther, there can be no doubt that the interplanetary and interstellar spaces are not empty, but are occupied by a material substance or body, which is certainly the largest, and probably the most uniform body of which we have any knowledge."[1]

To these three classes of material substances we must add yet a fourth, provisionally at least, in view of the peculiar energies which it displays, I mean that of living organic substances; our imagination of these being formed no longer by way of restriction or abstraction, but rather by combining the imagination of those energies which we have severally recognised as requiring each a different state of matter, chemical affinities being taken as the foundation. Supposing living protoplasm, or a living organism, to be once constituted, and abstracting from the question—In what precisely its *differentia* consists,— the energies displayed by it are all referable to one or more of the classes of energies, or their subdivisions, just

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[1] From J. Clerk Maxwell's article *Ether*, or *Æther*, in the Encyclopædia Britannica. Ninth Edition. Vol. VIII., pp. 569 and 572.—In Von Helmholtz's recently and posthumously published Lectures on the Electromagnetic Theory of Light,—a theory due to the genius of the author of the article on Ether just quoted, basing himself on the discoveries of Faraday,—Von Helmholtz speaks as follows of the required properties of the ether: "The subjects of change in the vibrations are the electric or magnetic polarisations of the medium in which they take place. In order to explain the propagation of light in space between the stars, which is free from all trace of ponderable matter, the electromagnetic theory of light also must assume a medium, which fills the world-space even where no ponderable matter is to be found. It must so far make the same assumption as the undulatory theory (of light); but while the latter has to ascribe the properties of a solidly-elastic body to the ether, no assumption at all need be made by the electromagnetic theory as to the mode of its inner consistence. It is enough, that the ether is capable of being magnetised, and electrified in the fashion of an insulator, that is, in such a way that in its smallest parts a certain electric distribution, a so-called dielectric polarisation, as Faraday named it, is possible."—*Vorlesungen über die Elektromagnetische Theorie des Lichts*. H. von Helmholtz, Herausg, von A. König und C. Runge. 1897. Zweiter Theil. § 13, p. 43.

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distinguished, dynamical, chemical, and electro-magnetic, and may be correlated with others belonging to the same classes. This I imagine is the reason why Heath includes Physiology among the sciences connected by the principle of correlation. But though living organisms can come in and take their share in the production of energies of one kind by expenditure of energies of another kind, yet a living organism, or any portion of living matter, if its life be once destroyed, cannot be reproduced, nor, so far as we know, has one ever yet been produced originally by such an expenditure alone, but always from and out of some pre-existing life. A clear and deep distinction must therefore be drawn between the energies and combinations of energies (if we so call them), which are constitutive of the nature and existence of a structure so unique and complex as living matter, and the other energies which, when constituted, it displays in interactions of various kinds, chemical, electrical, magnetic, dynamical.

Now it is to Matter existing in one or other of these four ways, or in some or all of them combined, that all the different kinds of energy in the material world are to be referred, if they are to be fully and scientifically understood and explained; I mean to matter as studied in Dynamic, matter as studied in Chemistry and in Biology, and matter hypothetically assumed as the immediate agent in light, radiant heat, electricity, and magnetism. The case of electricity will serve to make clear the meaning I would convey.

"We have as yet," says Professor J. E. H. Gordon, "no conception of electricity apart from

the electrified body; we have no experience of its independent existence."[3] It is however found, that in electrified bodies all electrification is of two kinds, vitreous or positive (+), and resinous or negative (−); that similar electrifications repel, dissimilar attract, each other; and also that if equal quantities of the two kinds of electricity be added together, they neutralise each other.[4] Electricity may thus be regarded as a quantity, and so also may each of its two kinds, the positive and the negative. Moreover,—"*For purposes of calculation electricity of either kind may be treated precisely as if it was a material incompressible fluid.* It however differs from a fluid in the fact, that equal quantities neutralise each other, for we cannot conceive two material fluids such, that when they are mixed, both should disappear."[5]

Having next spoken of Electricity in hollow conductors, and of Induced Electricity, and having stated Coulomb's Law of Electric Force, "The force of attraction or repulsion between two electrified bodies, whose sizes are very small in comparison with their distance apart, varies inversely as the square of their distance apart,"—Gordon thus proceeds: "The phenomena of electric attraction and repulsion, as well as those of induction, show us that the influence of a body charged with electricity extends for a considerable distance all round it, for it can act on bodies at a distance from it. The question 'How is this action conveyed across the intermediate space?' is the most

[3] *A Physical Treatise of Electricity and Magnetism.* By J. E. H. Gordon. 1880. Vol. I. p. 1.

[4] *Ibidem*, pp. 2 and 3.

[5] *Ibidem*, p. 14.

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important in all electrical science." * * * "There is no doubt that there must be some physical and material connecting link whenever electrical action of any kind is transmitted from one body to another. The only manner in which we can in any way account for the observed facts of attraction, repulsion, and induction, is by assuming that *the forces are transmitted by a strain or distortion of the medium which fills the space between the electrified bodies.*"[6]

Presently he adds: "In addition to being transmitted through air, glass, and other insulators, it is found that the electric forces are transmitted, not only across the best vacua we have as yet been able to produce artificially, but certainly also across the inter-planetary spaces.

"There is no doubt that the earth is affected by electrical phenomena occurring in the sun.

"Now we know that in these spaces there is no matter such as we are commonly cognizant of, and we must therefore suppose them to be filled with matter in an excessively attenuated state.

"We call this matter '*Ether*,' and suppose it to be a fluid many million times thinner than air, and having very great elasticity.

"In the fourth part of this work we shall endeavour to show that this ether is the same medium which conveys the light and heat from the sun to the earth—that is, that Light, Radiant Heat, Electric and Magnetic Induction are all different disturbances of the same ether-sea."[7]

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[6] *Ibidem*, pp. 19—20.

[7] *Ibidem*, pp. 21—22.

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It will be observed that radiant heat only is spoken of. What then, it must be asked, is to be said of heat as we commonly know it, heat produced in visible and tangible bodies by chemical and mechanical processes? The answer is, that heat of this kind, in which no mention is made of its transmission across vacua whether small or great, is to be conceived as a particular kind of molecular motion capable of spreading from body to body, as when water is stirred by a stick, and waves are propagated from the point of origin; as a motion moreover which is capable of velocities so great as to spread into the interior of the molecules themselves, thereby producing combustion, which is a chemical change, as for instance in striking a light with a match.

Heat is accordingly treated as a particular province either of Dynamic or Chemistry, under the titles of Thermodynamic or Thermochemistry. In this way its phenomena are treated as what in fact they are, an intermediary link between those of dynamic and chemistry, and in some sort the central phenomena, exhibiting the central kind of energy, in the whole circle of the sciences and of the phenomena which belong to them. Heat as a specific energy is in fact the chief agency in changing the states of homogeneous bodies, that is, carrying them out of and into the three states of which they are susceptible, namely, the solid, liquid, and gaseous states,—in which character it belongs most properly to Dynamic;—and also in effecting chemical changes of composition and decomposition, which depend ultimately upon chemical affinities. "The discovery," says Heath, "that

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Quantity of Heat ranks, as a numerically measurable thing, with dynamical work done, has made the production and expenditure of heat the central phenomenon which connects all branches of physical science."[8]—The properties of that fourth or ultra-gaseous state of matter, belonging to the series, solid, liquid, and gaseous, just mentioned, to which Sir William Crookes, following the lead of Faraday, its first suggester, gave the name of "Radiant Matter" (see his well-known Address at the Sheffield meeting of the British Association in 1879), including the nature of its connection with heat, as well as the relations in which it must be supposed to stand to the Ether, are questions which cannot properly be entered on in a sketch so rudimentary as the present.

It was in the course of a series of carefully devised and varied experiments made by Joule, beginning with researches in electro-magnetism, and extending over several years, from 1838 to 1849, that the first experimental proof was given of "the mechanical equivalent of heat," whereby the firm experiential foundation was completed, enabling and establishing the great generalisation known as the Correlation of Energies.[9] Joule's final result was given in a paper communicated to the Royal Society by Faraday, in June 1849. In

[8] *Work cited*, p. 94.

[9] See *Memoir of James Prescott Joule*, by Osborne Reynolds, F.R.S., &c. Published by the Manchester Literary and Philosophical Society, 1892; being Vol. VI. in the Fourth Series of their Memoirs and Proceedings.—On Mayer's claim to have anticipated Joule in this discovery, or rather on the nature of their respective claims in regard to it, see a paper by Von Helmholtz, entitled *Robert Mayer's Priorität*, written in 1883, and published as an Appendix to a Lecture given by him many years before, *Über die Wechselwirkung der Naturkräfte* in his *Vorträge und Reden*, 1884. Vol. I., pp. 60 to 74; from which it appears that, as stated above, the conclusive experimental proof belongs entirely to Joule.

this paper Joule says: "I will therefore conclude by considering it as demonstrated by the experiments contained in this paper,—

1st. That the quantity of heat produced by bodies, whether solid or liquid, is always proportional to the quantity of force expended.

2nd. That the quantity of heat capable of increasing the temperature of 1lb. of water (between 80° and 60°) by 1° Fahrenheit, requires for its evolution the expenditure of a mechanical force represented by the fall of 772lb. through one foot."

"This," says the writer of the Memoir from which I quote, "was Joule's final result, and is still accepted, as expressing the true value within the limits of accuracy of any known means of determination; while it now enters into almost all physical calculations as well as those which guide the practical conversion of heat into 'work.'"[10]

Heat was now finally and necessarily dismissed from the category of so-called imponderable substances, and conceived as a mode of motion in substances, that is, as an energy.[11] And this result, which established the great generalisation of the Correlation of Energies, also carried with it the subsumption of all the phenomena embraced by that generalisation, that is, all the different energies of Nature, under the single law of the Conservation of Energy, a law which, as we have seen, was originally discovered in Dynamic, together with the discovery of the nature of energy, as consisting of

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[10] *Memoir*, above cited, pp. 131 to 132.

[11] See *Heat considered as a Mode of Motion*, by John Tyndall, F.R.S., etc., etc., Chapter II. (2nd edition, 1865). On the whole subject of the present Section, this work will be found invaluable, at least to all who are not already experts.

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two inseparable modes, potential and kinetic. The *Correlation of Energies* means, that all the different kinds of physical energy, or modes of motion in physical substances, are measurable by and convertible into one another, either directly or indirectly; or that an equal quantity of one or more kinds of energy is producible by the expenditure of an equal quantity of one or more other kinds, but only on condition of this expenditure, and supposing also that we know the right means to employ for effecting any desired substitution. Moreover it followed that, when the Correlation of Energies in Physics generally was thus added to and combined with the law of Conservation originally established in Dynamic, there was thereby also laid open the possibility of a new science, treating of energy in general, the science of Energetic, side by side with the various particular sciences devoted to special classes of physical phenomena; a science in which the quantitative relations of energies to one another might be calculated, while abstracting from any special consideration of the nature of the substances which generated them. Or rather, the various special sciences became thereby susceptible of a new grouping and nomenclature, according to the particular correlation or correlations of energies which were fixed upon as the chief subject of study.

"We recognise," says the author of a recent Manual of Electro-chemistry, "five distinct kinds of energy, as follows:—

1. Mechanical Energy.
2. Heat Energy.
3. Electrical Energy.

4. Chemical Energy.
5. Radiant Energy.

These different forms of energy are capable of changing, one into another. For some of them arbitrary units have long been accepted. In the case of mechanical energy, for instance, the unit commonly employed in technical applications is that quantity of energy which is expended in raising a gram-weight one centimeter high.

"For the scientific measurement and expression of quantities of mechanical energy, the centimeter-gram-second system is in common use. According to this system the unit of work, the erg, is the work which is expended in moving the unit of mass (the mass of a gram), the unit distance (the centimeter), against the unit of force (the dyne). The dyne or unit of force has been chosen as that force which, in one second, produces in the mass of one gram an acceleration of one centimeter." [12]

It was the late Professor Rankine who first proposed the phrase "potential energy," contradistinguishing it from "actual," subsequently called "kinetic" in Dynamic, "to denote that power of performing work which is due to configuration, and not to activity," in a paper *On the General Law of the Transformation of Energy*, read before the Philosophical Society of Glasgow, Jan. 5, 1853.[13] This paper commences as follows:—

[12] *The Elements of Electro-chemistry.* By Professor Max Le Blanc (Leipzig). Trans. by W. R. Whitney. Macmillan. 1896. Pp. 1—2. In the above enumeration of kinds of energy, it would seem that we must understand magnetic energy as included under electrical.

[13] Reprinted in his *Miscellaneous Scientific Papers*, London, 1881, p. 203. See also another interesting paper, read before the same Society, in defence of his suggestion, Jan. 23, 1867, *On the phrase "Potential Energy," and on the Definitions of Physical Quantities. Ibidem*, p. 229. He notes, however, the prior use of a very similar phrase by Carnot, *force vive virtuelle*, though in a purely mechanical sense.

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"Actual or Sensible Energy is a measurable, transmissible, and transformable condition, whose presence causes a substance to tend to change its state in one or more respects. By the occurrence of such changes, actual energy disappears, and is replaced by

"Potential or Latent Energy; which is measured by the product of a change of state into the resistance against which that change is made.

"(The *vis viva* of matter in motion, thermometric heat, radiant heat, light, chemical action, and electric currents, are forms of actual energy; amongst those of potential energy are the mechanical powers of gravitation, elasticity, chemical affinity, statical electricity, and magnetism)."

The subject which he had thus laid open Rankine shortly afterwards pursued in his *Outlines of the Science of Energetics*,[14] contained in a paper read in May, 1855, before the same Philosophical Society, in which he lays down three axioms as those on which it depends:

"First Axiom: *All kinds of Work and Energy are Homogeneous.*—This axiom means, that *any kind of energy may be made the means of performing any kind of work.* It is a fact arrived at by induction from experiment and observation, and its establishment is more especially due to the experiments of Mr. Joule. * * * It is the truth of this axiom which renders a science of energetics possible. * * * This axiom is also equivalent to saying that *energy is transformable and transferable*; * * for, to *transform energy*

[14] Reprinted in his *Miscellaneous Scientific Papers*, pp. 209 to 228.

means to employ energy depending on accidents of one kind in putting a substance into a state of energy depending on accidents of another kind; and to *transfer energy* means to employ the energy of one substance in putting another substance into a state of energy, both of which are kinds of work, and may, according to the axiom, be performed by means of any kind of energy.

"SECOND AXIOM: *The Total Energy of a Substance cannot be altered by the Mutual Actions of its Parts.* * * * It follows, from the second axiom, *that all work consists in the transfer and transformation of energy alone;* for otherwise the total amount of energy would be altered. Also, that the energy of a substance can be varied by *external efforts alone.*

"THIRD AXIOM: *The Effort to Perform Work of a Given Kind, caused by a Given Quantity of Actual Energy, is the Sum of the Efforts caused by the Parts of that Quantity.* * * * "This axiom"—and the circumstance is significant—"appears to be a consequence of the definition of actual energy, as a capacity for performing work possessed by each part of a substance independently of its relations to other parts, rather than an independent proposition."

It is no doubt perfectly true, that all energy is ultimately derived from *vis insita* inherent in substances or in parts of substances, without reference to other substances or other parts. But if in Energetic we are to treat all kinds of energy as transformable and transferable (by Axiom I.), and if all work consists in the transfer and transformation of energy alone (by Axiom II.), it would

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prima facie at any rate not only seem advisable, if possible, to avoid a reference to the parts of substances possessing actual energy, but also that what is here wanted in lieu of, or at any rate in addition to, the present Axiom, is a statement of some general fact or principle governing the order of sequence of those transformations and transfers of energy in which work consists, when substances (whatever they may be) possessing different kinds of energy are in presence of one another. Some axiom specially relating to the order in which transferences and transformations of energy take place would seem still to be a desideratum, with men of science who have in view the complete organisation of Energetic as a science. Rankine deals with questions of this kind as belonging rather to the application than to the constitution of the science, giving, as he proceeds to do, mathematical methods for treating them, under the respective titles of the *Metamorphic* and the *Metabatic Functions*.

Now it would seem that, in contemplating any system of substances undergoing changes of energy, we can hardly avoid considering it, at any given moment, as engaged in following a certain order in the sequence of its changes, an order which it would continue to follow, provided it were left undisturbed by action from without; just as, in Dynamic, a single particle is considered as continuing in its state either of rest, or of uniform motion in a straight line, unless acted on by other particles. Nevertheless it would appear, that the third, or rather what is more usually called the second law of energy,—taking Rankine's law of conservation

of energy as the first law,—has not hitherto met with an expression universally agreed upon.

"The first law of energy is: *Energy cannot be created nor destroyed*, i.e., *the total amount of energy is constant.* This does not, however, preclude the possibility of the transformation of one kind of energy into another. It is the second law which deals especially with this point. This may be enunciated in many ways. It is thus expressed by Clausius: 'Heat cannot pass of itself from a lower to a higher temperature.' The general statement of Nernst expresses the same thing in a slightly different way which is preferable to the above: '*Every process which takes place of itself (that is, without external aid), and only such a process, is capable of doing a certain definite amount of external work.* This principle must be considered as a conclusion drawn from experience. Conversely also we may deduce the principle that an application of external work is necessary to cause a process which takes place of itself to proceed in an opposite direction.' Accordingly work is necessary in order to bring heat from a lower to a higher temperature, since the reverse process takes place of itself."[15]

The idea of processes which take place of themselves being the only processes which can do external work would seem to be precisely parallel, in transformation and transference of energies, to the idea of configuration of parts as the source of the potential, as distinguished from the kinetic, form of energy in Dynamic. The transformation

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[15] *The Elements of Electrochemistry*, above cited, pp. 132-133.

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of energies of specific kinds, their potential and kinetic forms included, into energies of other specific kinds, similarly including their potential and kinetic forms; and the transference of energies from one substance to another; these are the special subjects of the various departments of Energetic. The interchange between the potential and kinetic forms of one kind of energy only, the mechanical, is the special subject of Dynamic.

True, neither the transformation nor the transference of energies can take place without that interchange between the potential and kinetic forms which all change of energy involves. So that, whereas in Dynamic we had kinetic energy doing work, which when done had the form of potential energy or energy of configuration, and *vice versâ*, both forms of energy being of the same kind, what we have in Energetic is an interchange of potential and kinetic energy of one kind operating to produce an interchange of potential and kinetic energy of another kind, and to substitute the latter for the former; as for instance, where the chemical energy of a Daniell cell operates to generate the energy of an electrical current. And what is meant by *work* in energetic is nothing more than that quantity of any kind or kinds of energy which measures the energy, of some other kind or kinds, expended in producing it. In energetic we have total energies of different kinds in actual interchange with each other, as well as severally passing through changes between their own potential and kinetic states. The fact therefore is clear, that the laws of transformation and the laws of transference of energies,—and not merely the laws

of interchange between the potential and kinetic forms of any single energy,—are that which any special department of Energetic must have it in view to ascertain and establish.

It is moreover in these special departments of Energetic, including the energies of organic and living substances as well as those of inorganic matter, and in laboratories devoted to experiment and observation of the phenomena which they display, as well in conjunction as in isolation, that the main and proper work of positive science is done. For in them the scientific effort is continually directed to connect the energy or energies studied with the particular kind or kinds of matter, of which they are severally the operations. The ideal result of this effort, seen in forecast, would consist not only in exhibiting the ground of that intimate union and co-operation between electricity, magnetism, and chemical affinity, by his discoveries in regard to which Faraday initiated a new, that is, the present era, in electrochemical theory; not only in confirming Clerk Maxwell's electromagnetic theory of light, a theory also founded on Faraday's conceptions;[16] but also, generally, in relating all the different energies of Nature without exception to one another, by showing to what particular configuration of Matter and mode of Force the

[16] On both these subjects see Von Helmholtz's Address to the Chemical Society of London, on occasion of Faraday's Commemoration, April 5, 1881, entitled *Die neuere Entwickelung von Faraday's Ideen über Electricität*, reprinted in his *Vorträge und Reden*, Vol. II., pp. 273 sqq. 1884.—See also, on the latter subject, Herr Professor Hertz's Heidelberg Address, 1890, *Über die Beziehungen zwischen Licht und Electricität* (Strauss, Bonn. 1890), in which he gives an account of his own experimental demonstration, in support of Clerk Maxwell's electromagnetic theory of light, that the transmission of electric or magnetic energy, precisely like the transmission of light, for even the minutest distances, is not instantaneous, but requires a proportionate time for its accomplishment.

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origin of each was traceable, and by thus assigning to each its place in a single co-ordinated system.

Such, I conceive, is the true and proper task of physical and physiological science. Supposing it fully accomplished in every branch, the work of these sciences would be done, and their end attained. But then to establish this complete connection between kind or form of matter and kind or form of energy, so as to explain the latter, both in nature and genesis, by referring it to the former, is just the very hardest and most obscure part of the whole task. Such at least is the consummation to which our logical instinct points, as enabling us to grasp the largest possible number and variety of details from the smallest possible number of central and co-ordinating conceptions. Not that this ideal is the only one. There is another ideal in positive science, and one which takes precedence even of this. I mean the aim of discovering the actual state of *facts*, whether that discovery gratifies our logical instinct or not. If truth to fact is the end which we seek in science, it may well be, that our logical instinct can never by it be fully gratified. Nevertheless, unless and until either this task is performed, or it has been shown how it is that the facts forbid its performance, all gratification of the logical instinct, however apparently complete, must of necessity be illusory. Our logical instinct bids us go as far as possible in the co-ordination of facts, but it contains no promise that a knowledge of all existing facts, which alone would render a complete co-ordination possible, will ever be within our reach.

§ 3. Chemistry.

§ 3. The foregoing brief consideration of the Correlation of Energies as the object-matter of Energetic must be taken as an account, sufficient for the purposes of the present work, of the various physical sciences which treat in detail of the different groups of phenomena depending on those correlations. Nevertheless since psychology is the science which is most closely, and indeed inseparably, bound up with philosophy; and since psychology depends most immediately on biology, and biology again cannot be understood except by showing its intimate union with chemistry, it is necessary here to give some special though very brief account of the nature and scope of the two latter sciences, and of the place they hold in the whole chain of positive scientific knowledge. To chemistry, then let us turn.

In chemistry the object-matter which we have before us consists of (1) the intrinsic differences of compound physical substances, differences extending to the minutest particles, technically called *molecules*, in which their specifically different properties or qualities are found to inhere; (2) the intrinsic differences of simple or elementary substances, also inherent in their molecules; and (3) the different energies displayed by and between those various substances, both simple and compound, that is, their various combining affinities, in consequence of the intrinsic properties or qualities of their molecules. [1]

[1] "It is the molecules in which the qualities inhere. Hence the chemist's definition of a molecule: *The smallest particles of a substance in which its qualities inhere, or the smallest particles of a substance which can exist by themselves*; for both definitions are essentially the same."—From *The New Chemistry*, by Professor Josiah Parsons Cooke, LL.D., Harvard University. Eighth edition remodelled and enlarged. In the International Scientific Series. Kegan, Paul, Trench and Co., London, 1884, p. 100.

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The chemist's problem is, and the chemist's efforts are directed, in the first instance, to explain the specific qualities and energies of the molecules of the various compound substances, as they are experientially known in the aggregate (the molecules severally being too minute for presentative perception), by referring them to the specific qualities and energies of the molecules of the simple substances composing them, and then in the second place to explain the specific qualities and energies of the simple molecules, or molecules of simple substances, by referring them to differences of mass, volume, shape, weight, number, and configuration, or relative position, in the ultimate particles, technically called *atoms*, of which the least concrete molecule of any substance, simple or compound, is hypothetically assumed to be composed.

The chemist's purpose is to push his analysis of the intrinsic properties of matter to the utmost possible limit. It is in the least possible, or ultimate, atoms of concrete matter that the *vis insita*, inherent in all matter, must be considered to reside, that force which is one of the inseparable constituent elements of all matter, and indispensable to its real existence. Atoms themselves are thus resolvable into inseparable "elements," which are incapable of an independent existence. "We are brought," says the writer of the Manual which I have already quoted, and to which I with pleasure acknowledge myself signally indebted, at the end of his work, "we are brought to this general conclusion: the chemical relations of the atoms depend in the first place on mass, and in the second place on their inherent motion, and the ultimate

elements of each immutable atom are a definite mass and a definite mode of motion."[2]

It must, however, be remembered, that the specific properties and energies of physical substances due to the intrinsic differences of their molecules, or to the differences of mass, energy, or configuration of atoms, taken as the ultimates which compose molecules, which we may call their strictly chemical properties and energies, are never displayed in isolation from the other energies of Nature, dynamic, thermic, electro-magnetic, and etherial. This was made, I trust, sufficiently clear in the foregoing Section. It is a truth more especially to be borne in mind in biology, and in its daughter-science psychology. For if, as Faraday held, chemical and electric energy are ultimately identical, and if the hypothesis of an all-pervading Ether is our only means of rendering electric and magnetic action intelligible, as being that kind of matter in which these energies are displayed, it follows that the part played by the Ether, in all chemical, biological, and psychological phenomena must be of preponderating importance, entering into the last-named phenomena in virtue of its presence in living neural substance, the physical properties of which belong to the biological domain. But our knowledge of the Ether, and of the phenomena which are specially attributable to it, is as yet in its infancy. It is therefore only as a *caveat* that I interpose these few remarks. To return now to what may be called the specifically chemical phenomena.

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[2] *The New Chemistry*, p. 393.

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By a different kind of matter can be meant, as already said, neither more nor less than a different structure and configuration of the ultimate seats of its *vis insita*, that is, a different mode in which that *vis insita* occupies space; those ultimate seats of *vis insita*, which are called atoms, being assumed to be homogeneous for every specifically different simple or elementary substance. When, for instance, chemists speak of hydrogen being different in kind, or intrinsic properties, from oxygen, and both alike from the water which results from their combination in certain definite proportions, and replaces them, what they must be understood to mean is, that a single molecule of hydrogen and a single molecule of oxygen are each inseparable from that particular structure and configuration of its component atoms, or ultimate seats of its *vis insita*, which give to it the properties of hydrogen or of oxygen. Not that the particular structure or configuration then in view is necessarily an ultimate fact in nature, but that the specific properties of the molecules in question have not yet been traced to any other condition with greater probability than to the existence of a certain structure and configuration of atoms specifically the same for each specifically different molecule, and specifically different from those of atoms composing molecules of other kinds.

This way of thinking is not only legitimate, but in the present state of knowledge necessary. It cannot for a moment be supposed, that any such thing as *vis insita per se* abstracted from its occupancy of space is possible, any more than space occupancy is possible abstracted from *vis*

insita, or force in its lowest terms. For to suppose differences of kind in *vis insita* alone would require us to hypostasise it as an independent existent, a proceeding which, as we have already seen in the case of energy, involves a fallacy. The differences of kind in *vis insita* must therefore be identical with the different modes in which it occupies space; that is, ultimately—supposing matter in the gross to be divisible into constituents which are separable portions of matter—identical with differences in the number and relative position, or in one word the configuration, of and in equal homogeneous atoms, or *minima* of matter in the strictest sense.

At the same time—and this is in perfect harmony with the foregoing reasoning—it is also impossible, that all force should be extrinsic, and none intrinsic, or all be force due to configuration, and none inherent in the *minima* entering the configuration. This would be force exerted by nothing on nothing. The fact and the conception of intrinsic force, whether it be displayed in one definite mode or in several, are therefore indisputable. But this does not mean that those modes of intrinsic force which for our present knowledge are ultimate, that is, incapable of analysis into other intrinsic forces, are the real ultimates of Nature.

On the contrary it is perfectly conceivable, taking the material world as a single whole, that but one single kind of atom, with its single kind of *vis insita*, but with some variety in the grouping of the atoms, giving rise to variety of action between them,—or some other state of matter differing in some other way, but still only slightly, from a state of perfect homogeneity,—should have

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once existed, and served as the ultimate basis and parent of all those specifically different substances, with their energies, the relations between which are what Chemistry seeks to explain. Such a state would of course afford no explanation whatever of the coming into existence either of matter or of force. At the same time its existence would be open to no logical objection, since some state or other must be conceived as the initial one, and this would, by hypothesis, serve as the origin of a real evolution of the present rich variety of physical substances and energies. To demonstrate the nature and existence of such an initial state of matter may perhaps be regarded as the ideal goal and crowning triumph of chemical science. The result, however, would clearly be, to bring the whole of chemistry (theoretically speaking) under dynamic, by exhibiting all chemical energies as depending ultimately upon different modes of dynamical stress.

But at the present day the chemical elements which resist further analysis, and are ultimate for our present knowledge, are some seventy or more in number; and the tendency of the science is rather to increase than diminish the list. Each of these elementary substances is, on the atomic theory, composed of atoms peculiar to itself, differing in weight from the atoms composing every other of them, the different weights of every kind of atom relatively to the rest having for the most part been ascertained, and expressed by a number, in which the weight of the hydrogen atom, or (same thing) of the half hydrogen molecule, is taken as unity. And these numbers are found to

express the proportions by weight, in which, or in multiples of which, all combinations of different elementary substances, or particular formations within the elementary substances severally, take place; which general fact is known by the name of the law of multiple proportions.[3] "When two elementary substances combine, it must be that a single atom, or some definite number of atoms, of one unites with a definite number of atoms of the other,. and therefore the combination must take place either in the proportion of the relative weights of the atoms, or in some simple multiple of that proportion. Moreover, when in any chemical change a new grouping of the atoms takes place, the same relative proportions must be preserved."[4]

Chemical energies, then, are those which spring from differences in the intrinsic nature of the material substances between which they are exerted; or, otherwise stated, those which depend upon the intrinsic qualities of the material particles which display them in mutual interaction. Chemistry is the science which studies the laws of these energies, and of the composition, decomposition, and recomposition, of the substances which display them; always of course in connection with the laws of matter studied by other sciences, but still always as energies which have a specific *differentia* of their own. This specific character consists, as already noted, in the fact that, while they are exerted extrinsically, or after the fashion of *vires impressæ*, from one material particle to

[3] *The New Chemistry*, pp. 75. 128. 131. 136.
[4] *Ibidem*, p. 133—4.

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another, they are determined, or made what they are in kind, by the intrinsic properties of the material particles which exert them.

Building on this, its own additional conception of energies depending on intrinsic differences of matter, chemistry is enabled to push the analysis of the nature of matter much farther than is done by dynamic, or any branch of physical science which deals with ponderable matter only. I mean, that it analyses molecules of matter, which are the ultimate particles known to other sciences, into ultimates of its own, called atoms, assigning to every one of its seventy or more elementary substances its own specific weight, or *quantum* of atomic matter. "All substances are collections of molecules, and in these molecules their qualities inhere. What is true of the substance is true of the molecule. The molecule is an aggregate of atoms; sometimes of atoms of the same kind, as in elementary substances, sometimes of atoms of different kinds, as in compound substances. The molecules are destructible, while the atoms are indestructible; and chemical change consists in the production of new molecules by the re-arrangement of the atoms of former ones." [5]

We see from this, that chemical atoms, that is, the atoms spoken of in chemistry, are not the same as what may be called ultimate physical atoms, or minima of matter, supposing such minima to have a separable existence. These latter, since the idea of them is arrived at by purely general considerations of the nature of matter, must necessarily be conceived as equal, and would naturally be con-

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[5] *The New Chemistry*, p. 150.

ceived also as homogeneous in every respect. Chemical atoms, on the other hand, are hypothetical constituents of molecules, introduced to account for the specifically different properties of elementary substances. They may be conceived like molecules again, only on a smaller scale; that is, may be supposed to have each its own intrinsic size, shape, and weight, or *quantum* of matter, the same for all those that compose the molecules of every specifically different elementary substance; and also to be possibly again divisible into still smaller constituents, not as yet demonstrable by experiment. This difference between the atoms spoken of in chemistry and the atoms, or equal and homogeneous minima of matter, which correspond to an idea in the physical conception of it, is due to the strictly experiential way in which chemistry deals with its object-matter. For which reason it is, that the identification of chemical atoms with what I have called ultimate physical atoms,—which latter are purely ideal,—remains a problem for the future.

Nevertheless the step forwards taken by chemistry, in consequence of distinguishing chemical from other physical energies, is enormous. It is in chemical phenomena that Individuation of Kinds of physical substances takes its rise, being rooted in the specific differences of intrinsic qualities in matter. This must not be confused with the Individuality of real existents spoken of in § 9 of the preceding Chapter, and there distinguished from the generality which belongs to concepts. This last named individuality is presupposed in all the existents with which we are

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now dealing. Every particle of matter chemically considered, that is to say, ultimately, every chemical atom, belongs to a class the members of which are material existents having the same special intrinsic character. We have met with specific differences before; as for instance, those of the different kinds of sensation or feeling generally, sound, colour, sense of effort, and so on; or those of shape and figure, as curve and straight; round, square, cube, &c.; but we have not before met with specific differences in material existents, intrinsic to them as such, and therefore enabling us to distinguish them as material existents of specifically different kinds.

Whenever an intrinsic difference in chemical atoms or their configuration is requisite to explain the character of a substance, simple or compound, in comparison with others, there a real individuation of kind may be said to exist; every such substance has specific individuality, an individuality not simply numerical, not due to our comparison of it with others, which is but the origin of our knowledge of it, but real in the full sense of the term, an individuality in point of its nature or *whatness* as a physical substance, and founded in the nature and energies of matter. Thus the simplest chemical aggregates of molecules, the so-called chemical elements, or irreducible elementary substances, whatever they may be, are the first or lowest stage in what may be called a natural *scala generum*, that is, of specification in the nature and structure of single material existents, the highest stage in the scale being that which comprehends the most complex material living organisms, and

every stage of the scale having its own *quantum* of numerically different individuals belonging to it.

Chemical composition or structure, then, is the basis and first instance of the actual realisation of natural genera and species in Nature itself, and by the operation of natural energies; as distinguished from classifications imposed by the observer for his own convenience, notwithstanding that the latter may be founded on definite and constant differences in the objects observed, as for instance, of musical notes in the scale, of colours in the spectrum, of geometrical figures in the order of their increasing complexity. Classifications of this latter kind, it is true, are records of observed similarities and dissimilarities which Nature has generated; but classifications of the former kind depend, over and above this, on discovering the generating processes whereby those very material existents are produced, one out of another, which constitute Nature; or which, in other words, are real conditions as well as real conditionates, and of which all other observable similarities and dissimilarities are conditionates only. They are classifications of real agents in respect of their agencies; all others are classifications of results which are products of these, but have no real re-action upon them. To use the old Aristotelic phraseology in its modern and strictly justifiable sense, a classification of substances is a very different thing from a classification of attributes.

Chemical composition and structure, interchange of chemical energies, and specific differences distinguishing classes of material existents depending on them, attach to material existents of all kinds,

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from the lowest inorganic to the highest organic structures; and there is no sharply drawn line separating what is called organic chemistry from inorganic. This distinction is one of convenience, and arises only as an after consequence imported into chemistry from the study of living organisms. Certain chemical compounds, which were originally found only in living organisms or products of living organisms, were at first said to belong to organic as distinguished from inorganic chemistry; but many of these compounds have since been produced without the intervention of living organisms, and hence the distinction between organic and inorganic chemistry, as a fundamental one, has been abandoned. There is no fundamental difference between these two branches of the science. But from this, as will presently be seen, it does not follow that there is none between chemistry and biology, that is, between chemical and vital processes; or that living matter is capable of being generated originally by and out of non-living matter, and is not rather an ultimate, though not purely chemical, mode in which matter exists, as completely *sui generis* as are any of those purely chemical modes, to which we give the name of elementary substances.

The case stands thus. The substances of which living organisms consist, taken apart from their vitality, are chemical structures, developing chemical energies, and on this account the study of all living organisms belongs plainly to chemistry, though not to chemistry exclusively. So far as substances are living, they present these structures and energies in modes impressed upon them from some apparently

non-chemical source, modes of structure and energy to which their chemical structure and energy are necessary but subordinate; and to this extent they are the subject of the higher and more complex science of biology. "The chemist has never succeeded in forming a single organic cell, and the whole process of its growth and development is entirely beyond the range of his knowledge; but he has every reason to expect that, in the no distant future, he will be able to prepare, in his laboratory, both the material of which that cell is fashioned, and the various products with which it becomes filled during life." [6]

Thus, in living organisms, the structures and their energies belong ultimately to chemistry, but they are transformed and, as it were, utilised by processes acting under laws which seem to have some other nature and origin than merely chemical affinity. That is to say, the energies operative in living organisms, as such, cannot as yet be referred to the presence of any specifically different chemical substance, whether atom, molecule, or other more complex compound, as the sole and sufficient account of them. Living structures are included under chemical, inasmuch as they are chemical structures and something more; and living energies are included under chemical energies for the same reason. But this does not tell us, in what precisely this *something more* consists. The conception of chemical structure includes no specific concep-

[6] *The New Chemistry*, p. 323.—I would also here take occasion to acknowledge the great assistance I derived, when the first draft of the present Section was being sketched, from conversations with my friend Professor Wyndham R. Dunstan, F.R.S., on that subject of which he is a master, and more particularly on the points touched on in this and the preceding paragraph.

tion of living structure, nor does the conception of chemical energy include any specific conception of vitality. The function of the two more general conceptions, logically speaking, is to keep places open, in thought, for the two specific conceptions to occupy, if and when their characteristic differences are positively ascertained. The real question accordingly is,—What and whence the *differentia* of living structure and vital energy?

We have seen that individuation is founded ultimately in chemical differences which are intrinsic differences of kind. Every instance of a specifically different elementary substance, or aggregate of homogeneous molecules, is a material existent exhibiting a determinate mode of one and the same specific character. But it may exhibit it for a brief period only. The essence of all strictly chemical processes is change of substance; and whenever a structure undergoes chemical metamorphosis, either by composition or decomposition, it is lost as a structure, and becomes unrecognisable in the resulting products. The structure loses its specific character in strictly chemical change.

But there is one whole class of chemical structures, in which the specific character is not wholly lost when they undergo chemical change; or in which, as we may also express it, the chemical changes which they undergo are partial changes, not extending to the whole of the mass which is affected by them. Structures of this kind consist wholly or in part of some form or other of a certain living substance, met with in both the vegetable and the animal kingdoms, and peculiar to them, a living substance which, more especially in the vegetable

kingdom, is called protoplasm. Structures composed of this substance, or into which it enters as a constituent, exhibit the phenomena of life. They may undergo partial chemical changes and survive them, that is, remain living substances as before. And not only so, but may grow and develop in consequence of them; respiration, assimilation, and nutrition, for instance, being all of them chemical changes. To speak of this substance first in the vegetable kingdom.

The smaller zoospores of a small alga, *Hæmatococcus pluvialis,* better known as *Protococcus,* says Professor Vines, "consist of a minute mass of a jelly-like substance, granular and coloured green for the most part, but clear and colourless at the pointed end where it is prolonged into two delicate filaments termed *cilia;* the larger ones have the same structure, but they possess in addition a membrane through which the cilia protrude. To this jelly-like substance the name of *protoplasm* has been given, and, on account of its universal presence in living organisms, it has been described as the *physical basis of life.* It usually occurs, as in these cases, in the form of minute individualised masses, each such mass being termed a *cell.* The membrane which surrounds the protoplasm of the larger zoospores is the *cell-wall,* and it may be shown by appropriate tests that it consists of a substance known as *cellulose:* an investing membrane of this kind is present in the great majority of plant-cells, its presence is, in fact, the general rule, but it is not absolutely essential. The essential part of a living cell is its protoplasm, the cell-wall being a secondary

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formation, a product of the vital activity of the protoplasm."[7]

Presently he continues: "In considering the life-history of Hæmatococcus we observe that it maintains itself, that it reproduces its kind, and that at one period of its life it is endowed with the power of active motion; phenomena which necessarily imply that the organism is constantly obtaining supplies of matter and of energy from without."[8]

Having next taken the Yeast-plant (*Saccharomyces Cerevisiæ*) to examine, Professor Vines proceeds: "The protoplasm of the yeast-cell, and this is true of every living organism, is the seat of active chemical processes which are inseparably associated with the vital activity of the protoplasm. These collectively may be termed the *metabolism* of the organism. We may conveniently distinguish as constructively metabolic" [or anabolic] "those processes which tend to form more and more complex compounds in the organism, and as *destructively metabolic*" [or catabolic] "those processes which tend to break down the complex compounds with the formation of others of simpler composition." Some of these simpler products are eliminated as *excreta*.[9]

"The results of the constructive metabolism of the yeast-cell are then an accumulation of organic matter and of energy, the results of its destructive metabolism are a diminution of organic matter and a dissipation of energy."[10]

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7 *Lectures on the Physiology of Plants*, by Sydney Howard Vines, F.R.S., etc., etc., Camb. Univ. Press, 1886, pp. 1 and 2.

8 *Ibidem*, p. 2.

9 *Ibidem*, p. 4.

10 *Ibidem*, p. 5.

The fundamental properties with which the protoplasm of the Yeast-plant is endowed are then enumerated as (1) absorptive, (2) metabolic, (3) excretory, and (4) reproductive.[11]

Returning to the protoplasm of the zoospore of Hæmatococcus our author states that, in addition to the four properties just enumerated, "5, it is *contractile*, as evidenced by the movements of the cilia; 6, it is *automatic*, in that the exciting cause or stimulus which produces the contraction originates in the organism itself; 7, it is *irritable*, inasmuch as the movements of the organism may be modified by the action of external stimuli."[12]

But it is to be noted, that "Of these properties, some, such as those of absorption, metabolism, and excretion, are found to be possessed by the protoplasm of all living cells, whereas the others do not appear to be so universally distributed. It occurs comparatively rarely that, as in the case of the zoospore of Hæmatococcus, all these properties are exhibited by the protoplasm of one cell."[13]

In a later Lecture, on *The Food of Plants*, where the chemical substances of which they consist are considered, we read:

"The elements which have been found to be essential to the life of plants are the following: Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur, Phosphorus, Potassium, Calcium, Magnesium, Iron (in the case of green plants), and in certain cases apparently also Chlorine.

"Inasmuch as the so-called organic substances which are found in plants, such as fats and other

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[11] *Ibidem*, p. 6.
[12] *Ibidem*, p. 7.
[13] *Ibidem*, pp. 7—8.

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hydrocarbons, starch, cellulose, and other carbohydrates, proteids and their allies, consist of C and H, or of C, H, and O, or of C, H, O, and N, or of these together with S, or P, it is clear that these elements are of importance to the plant because they compose the substances of which the structure of the plant is built up. Further they are of importance because the complex substances which they form are readily decomposed and thus energy is set free; this will be fully considered in treating of the destructive metabolism of the plant.

"With regard to the other elements, it appears that they do not enter into the substances of which the tissues of plants consist; their importance being of this nature, that they promote the metabolism of the plant." [14]

Turning in the next place to the chemical composition of living substance in animals, it is found to be closely similar to, if not identical with, that of the vegetable kingdom. I quote from the Appendix, on *The Chemical Basis of the Animal Body*, by Dr. A. Sheridan Lea, F.R.S., &c., forming the fifth and concluding Part (or Vol.) to the fifth edition of Professor Michael Foster's well-known *Text Book of Physiology*.[15]

"The animal body, from a chemical point of view, may be regarded as a mixture of various representatives of three large classes of chemical substances, viz. proteids, carbohydrates and fats, in

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[14] *Ibidem*, pp. 123—124.

[15] *A Text Book of Physiology*. With Illustrations. By M. Foster, F.R.S., &c., &c.; Fifth Edition, largely revised. Macmillan and Co. 1891—1892.

association with smaller quantities of various saline and other crystalline bodies. By proteids are meant bodies containing carbon, oxygen, hydrogen and nitrogen in a certain proportion, varying within narrow limits, and having certain general features; they are frequently spoken of as albuminoids. By carbohydrates are meant starches and sugars and their allies. We have also seen that the animal body may be considered as made up on the one hand of actual 'living substance,' sometimes spoken of as protoplasm (see § 5)" [*i.e.*, of the *Text Book*] "in its various modifications, and on the other hand of numerous lifeless products of metabolic activity. We do not at present know anything definite about the molecular composition of the active living substance; but when we submit living substance to chemical analysis, in which act it is killed, we always obtain from it a considerable quantity of the material spoken of as proteid. And many authors go so far as to speak of living substance or protoplasm as being purely proteid in nature: they regard the living protoplasm as proteid material, which in passing from death to life has assumed certain characters and presumably has been changed in construction, but still is proteid matter; they sometimes speak of protoplasm as 'living proteid' or 'living albumin.' It is worthy of notice however that even simple forms of living matter, like that constituting the body of a white corpuscle, forms which we may fairly consider as the nearest approach to native protoplasm, when they can be obtained in sufficient quantity for chemical analysis, are found to contain some repre-

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sentatives of carbohydrates and fats as well as of proteids. We might perhaps even go so far as to say, that in all forms of living substance, the proteid basis is found upon analysis to have some carbohydrate and some kind of fat associated with it. Further, not only does the normal food which is eventually built up into living substance consist of all three classes, but, as we have seen in the sections on nutrition, gives rise by metabolism to members of the same three classes; and as far as we know at present, carbohydrates and fats, when formed in the body out of proteid food, are so formed by the agency of living substance, by the action of some living tissue. Hence there is at least some reason for thinking it probable that the molecule of living substance, if we may use such a phrase, is far more complex than a molecule of proteid matter, that it contains in itself residues so to speak not only of proteid but also of carbohydrate and fatty material."[16]

When in the next place we turn to the functions performed by animal living substance, we find those of them which are essential to the existence of life readily identifiable with the three named by Professor Vines, in the case of the yeast-plant, absorption, metabolism, and excretion. Thus Professor Foster, in summing up the results of a description of the main facts observable in living animals, writes as follows:

"The differences therefore between living substance and dead substance, though recondite, are very great, and the ultimate object of Physiology is to ascertain how it is that living substance can

[16] The above named *Appendix*, pp. 1—2,—the initial paragraph.

do what dead substance cannot, can renew its substance, and replenish the energy which it is continually losing, and can according to the nature of its surroundings vary not only the amount but also the kind of energy which it sets free. Thus there are two great divisions of Physiology: one having to do with the renewal of substance and the replenishment of energy, the other having to do with the setting free of energy."[17]

In the passage immediately following these words, Professor Foster proceeds to specify the amœba, which is one of the lowest or least differentiated of animal beings, as an instance of the exercise of the functions he has described. "The amœba is a living being; it renews its substance, replenishes its store of energy, and sets free energy now in one form now in another; and yet the amœba may be said to have no tissues and no organs; at all events this is true of closely allied but not so well known simple beings. Using the more familiar amœba as a type, and therefore leaving on one side the nucleus, and any distinction between endosarc and ectosarc, we may say that its body is homogeneous in the sense that if we divided it into small pieces, each piece would be like all the others. In another sense it is not homogeneous. For we know that the amœba receives into its substance material as food, and that this food or part of it remains lodged in the body, until it is made use of and built up into the living substance of the body, and each piece of the living substance of the body must have in or near it some of the material which it is about to build up into itself. Further, we

[17] The above named *Text Book*, Part I., § 3, p. 3.

know that the amœba gives out waste matter such as carbonic acid and other substances, and each piece of the amœba must contain some of these waste matters about to be, but not yet, discharged from the piece. Each piece of the amœba will therefore contain these three things, the actual living substance, the food about to become living substance and the waste matters which have ceased to be living substance." [18]

The equivalence or close analogy between the essential functions thus described in the amœba and those of absorption, metabolism, and excretion, signalised by Professor Vines in the instance of the yeast-plant, will, I think, be manifest. The fact also, that the amœba "can according to the nature of its surroundings vary not only the amount but also the kind of energy which it sets free," corresponds to the possession, by the zoospores of *Hœmatococcus*, of the functions named by Professor Vines contractility, automatism, and irritability. It would seem, then, that we must describe the lowest and simplest form of living substance as a highly complex chemical structure, differentiated from other chemical structures by the fact of its possessing an additional inherent energy, called in its case a function, namely, the energy or function of metabolism, the exercise of which comprises the exercise of the two component or contributory functions of absorption and excretion. We come in fact to structures which are biological units in addition to being chemical ones. "Just as in division of the chemical mass we come to the chemical molecule, further division of which changes

[18] *Ibidem*, Part I., § 4, pp. 3—4.

the properties of the substance, so in the continued division of the amœba we should come to a stage in which further division interfered with the physiological actions, we should come to a physiological unit, corresponding to but greatly more complex than the chemical molecule. (Such a physiological unit might be called a *somacule.*)"[19]

The nature of absorption, as the first step in the metabolic process, is thus the first and fundamental problem in biology, since it must be taken to involve the conversion of the substances taken up from the environment either into substances of kinds already present in the absorbent structure, or into substances of new kinds by combination with some of its already existing elements. In other words, the *differentia* of vital from merely chemical energies is to be looked for in that energy (inherent in structure) which, as regards the organism alone, is called metabolism, and as regards the relation of the organism to its environment, is called absorption and excretion. But since this energy is necessarily to be conceived as inherent in the organism *ab initio,* it follows, that the final problem of biology cannot be solved, unless the energy is not only discovered and described as an energy, but is also referred to the highly complex chemical structure, in which it is inherent as its specific energy. The *differentia* of life must, in other words, be discovered both as a specific energy, and as a specific structure in which, and in which alone, the energy is inherent. Thus Morphology and Physiology, the two main branches of Biology, mutually suppose and involve each other.

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[19] *Ibidem,* Part I., § 5, pp. 5—6.

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In a later Chapter Professor Foster points out that the white blood corpuscles, in the higher animals are capable of executing "amœboid movements," that is, "are able of themselves to change their form and by repeated changes of form to move from place to place. Such movements of the substance of the corpuscles are called amœboid, since they closely resemble and appear to be identical in nature with the movements executed by the amœba and similar organisms. The movement of the endoplasm of the vegetable cell seems also to be of the same kind."[20] The movements, in fact, are of the kind called contractile and automatic in a passage cited above from Professor Vines. And in a later passage taken from the Section last cited Professor Foster expressly vindicates contractility in the broad sense for the substance both of the amœba and of the white blood corpuscle, considering muscular contraction as a specialised kind.[21]

Now "the cell body of the white corpuscle may be taken as a good example of what we have called undifferentiated protoplasm."[22] And farther on we read, "In the broad features above mentioned" (features belonging to its chemical composition as well as to its morphology) "the white blood corpuscle may be taken as a picture and example of all living tissues. If we examine the histological elements of any tissue, whether we take an epithelium cell, or a nerve cell, or a cartilage cell, or a muscular fibre, we meet with very similar features. Studying the element morphologically, we find a

[20] *Ibidem*, Part I., §§ 28 and 95, pp. 38 and 166.
[21] *Ibidem*, Part I., § 95, p. 167.
[22] *Ibidem*, Part I., § 28, p. 39.

nucleus and a cell body, the nucleus having the general characters described above with frequently other characters introduced, and the cell body consisting of at least more than one kind of material, the materials being sometimes so disposed as to produce the optical effect simply of a transparent mass in which granules are embedded, in which case we speak of the cell body as protoplasmic, but at other times so arranged that the cell body possesses differentiated structure."[23]—The passage goes on to speak of its chemical composition; to this, however, it is not necessary for our present purpose to return.

But here the question must be asked, If the vegetable and animal kingdoms are so closely similar, both in the chemical constituents of their organisms and in the energies which those organisms display, what essential difference can there be between them; why do they not form one individual kingdom of life simply? Why, for instance, is the amœba classed as an animal, the yeast-plant as a vegetable? The answer is partly as follows:

"The *Amœba* is an animal, not because of its contractility or power of locomotion, but chiefly because it is devoid of the power of manufacturing protein from bodies of a comparatively simple chemical composition. The *Amœba* has to obtain its protein ready made, in which respect it resembles all true animals, and therefore is, like them, in the long run, dependent for its existence upon some form or other of vegetable life."[24]

[23] *Ibidem*, Part I., § 30, p. 41.

[24] *A Course of Elementary Instruction in Practical Biology*, by T. H. Huxley, P.R.S., &c., &c., and H. N. Martin, F.R.S., &c., &c. Revised and extended edition by Professors G. B. Howes and D. H. Scott, 1892. Chapter VIII., p. 37.

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Again, as regards the cells of the yeast-plant, which are called *Torulæ*. "The *Torula* being alive, the question arises whether it is an animal or a plant. Although no sharp line of demarcation can be drawn between the lowest form of animal and of vegetable life, yet *Torula* is an indubitable plant, for two reasons. In the first place its protoplasm is invested by a cellulose coat, and thus has the distinctive character of a vegetable cell. Secondly it possesses the power of constructing Protein out of such a compound as Ammonium Tartrate, and this power of manufacturing Protein is distinctively a vegetable peculiarity."[25]

It would seem, then, that, if we take absorption with conversion of substance as the first and fundamental problem of biology, it is in the vegetable world that the first beginnings of life must be expected to appear. For it is in vegetables that the conversion takes place of inorganic substances into protein; which is one, and not the least important, of the three classes of substances of which, as we have seen, protoplasm or living substance consists, namely, proteids, carbohydrates, and fats; and for the supply of this substance animals are dependent ultimately on vegetables. The question then presents itself as follows, What are the conditions of structure which enable plants to "manufacture" protein out of a non-proteid environment?

If, however, we assume, with many if not most biologists, that the earliest living organisms were of a kind not as yet differentiated into the two branches, vegetable and animal, we should still be

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[25] *Ibidem*, Chap. IX., p. 382.

met on this lower stage of life by the same question. Whence did these undifferentiated forms of life derive their protein; or, what was the origin of living protein? Professor E. Ray Lankester is of opinion, that this earliest form of living organisms was more akin to animal than to vegetable life. He considers that the Mycetozoa probably represent, more closely than any other living forms, the original ancestors of the whole organic world.[26] The whole question is of primary importance, as well as difficulty; a question on which the future progress both of chemistry and biology may be expected to throw light.

On the whole, then, we see, that there are certain specially constituted chemical structures which are no longer chemical structures simply, generating and interchanging simply chemical energies, but chemical structures which have, in addition, become living organisms, and whose chemical energies have taken on the additional character of vital functions. And these organisms have not only an individuality, but also a history of their own, in the full and proper sense of the term; that is to say, normally go through a definite series of changes, such as nourishment, growth, development in complexity and power, then gradually attain maturity, reproducing their kind, and then gradually decline in vigour, before their final decomposition. Concomitantly with these changes, the structures in question act on and are acted on by their environment, from which they also take up and assimilate their nutriment.

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[26] See his Article on *Protozoa*, in the Encyclopædia Britannica, Ninth Edition, Vol. XIX., particularly pages 831 and 832.

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They are thus no longer chemical structures merely, having specific individuality, but self-renewing, self-developing, and reproductive structures, having each an individual history; that is, they are living organisms performing functions during a single life-time; and these functions fall under two main heads, *ad intra* and *ad extra*, functions wherein the actuation or organosis (if I may so speak) of the structure consists, and functions whereby it enters into relation with the world outside it. All these functions depend ultimately on the inherent properties of the living substance on which their vitality itself depends, or of which it is the specific mode of activity.

This is another very distinct step forwards in individuation. A chemical structure of a specific kind has that specific character prolonged by means, and yet, in some sense, in spite of, the chemical changes which take place in it. As a complex structure it undergoes vicissitudes, while retaining its specific identity. It has a history of successive stages, belonging to it alone, from its generation to its death. It is what we call a single individual being, in the strict (though not the fullest sense), and the first instance of individuality, in that strict sense, which we have hitherto met with; just as its life-time is the first instance of history in the strict sense of that term, the sense in which it is applied in all the fulness of its meaning, to men and to communities. The process of real individuation begins, as we have seen, with chemistry; it is carried farther to completion in biology.

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§ 4. Life and living structures, then, must be conceived as coming into existence together, and

mutually involving each other. Their nature is most readily understood by conceiving them as modifications of structures and energies which, apart from them, would be merely physical and chemical, and then taking the first moment of the appearance of life to be that in which any merely chemical and physical structure becomes an organism, that is, acquires such a stability, founded on the differentiation, grouping, and interaction, of its elements, as thenceforward to exercise the functions known either as metabolism, or as absorption and excretion. Living structures, as we have seen, are chemical structures differentiated in such a manner as to exhibit, not chemical energies merely;—which as already noted must be taken to include all or any of the energies, mechanical, thermal, electric, magnetic, and etherial, which may be involved with those which are strictly chemical;—but life or vital energies also, which are functions of living organisms, that is to say, energies which, while effecting changes in the structures exercising them, yet partly by means of those very changes maintain and develop the structures themselves, throughout periods of time which, in each individual case, we call the natural or normal life-time of the structure.

But it must be noted at the outset, that the priority which is implicitly ascribed, in the foregoing paragraph, to chemical structures and energies, as compared to vital, is solely a priority in our order of thought, nothing being thereby prejudged as to the priority of either kind of factor in the order of real existence and history. The question whether chemical structures and

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energies were first in order of real genesis, that is, existed previously to the origin of any living organisms, is a question either for Biology itself, or for Natural History which is its historical department, to determine. By their priority in order of thought is meant only this, that they are a prior part or condition of our scientific knowledge of vital phenomena, or in other words, that we cannot understand or account for vital phenomena without first understanding chemical; in doing which we necessarily imagine chemical phenomena, being the less complex, as the foundation and condition of vital, which are the more complex.

It is in this same way that dynamical and physical phenomena are conceived as prior to chemical, notwithstanding that in their case it is difficult not to conceive them as co-eval in order of real genesis, or to conceive matter as not possessing mechanical, physical, and chemical energies at once and simultaneously. Life, it is true, is restricted to appear in certain chemical structures only, and to appear in these for certain time-durations only. This, however, does not alter the conceivable possibilities of the case. We have before us, at the present day, and existing side by side with each other, on the one hand structures of living protoplasm, on the other the chemical substances of which that protoplasm is composed, not forming part of it, but entering freely into other purely physical and chemical combinations. To understand living protoplasm it is thus clearly necessary for us first to understand, to some extent, the nature of its chemical components. But it is

equally clear, that, since life is reproduced from life, and, so far as our knowledge goes, from life only, structures of living protoplasm may have existed side by side with the purely physical and chemical forms of the elements of which it is composed, from times as far back in the history of real existence as our positive thought can carry us, just as they exist side by side with them at the present day. In this case, however, we must also suppose, that non-living matter furnished *ab initio* both the dwelling-place and the food of living matter,—a state of things, no indication of which is afforded by our knowledge of life on our own planet. It is even conceivable, that living beings, that is to say, structures of living protoplasm, or of some other kind of living matter, which are ancestors of those now living, were originally the only form or forms in which Matter itself existed, and which then exercised alone all those energies which we now know as purely mechanical, chemical, and physical. But similarly in this case, we must also suppose, that both the dwelling place and the food of what is now known as living matter were originally produced out of the substance, and by the activities, of the assumed primordial living matter.

Returning, then, with this *caveat* to the nature of life and living structures, and approaching the subject in the only way in which it can be approached on the basis of experience,—which is that circumstance which renders the *caveat* necessary,—the first question to meet us is this,—What account is to be given of the *differentia* of Life? Or more precisely, (1) What is the nature of organisms and their vital energies, (2) What is the

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real condition of their making their appearance among and in chemical structures? The nature, origin, history, and laws, of organisms and their vital energies, constitute the whole field of Biology, which is the last and highest of the purely physical sciences, including as it does all those actions of material living beings, upon which the existence and development of their consciousness as the object of psychology proximately depend. It begins, as we have seen, with the analysis of certain chemical structures, with a view to discover their constitution other than merely chemical, even with the inclusion of the other energies just specified. It seeks some mode or law of combination in those structures, which is the constant concomitant, or, if I may so speak, the structural expression, of their performing vital functions; or, which, in other words, distinguishes living from dead protoplasm; and this under the two main heads of Morphology and Physiology, into which the whole science may primarily be divided.

We know protoplasm only in two states, living and dead, during life and after its extinction; and our chemical knowledge of it is only of the latter. A pre-vitalised state of it, supposing it to be possible, is a *desideratum*; and not only so, but it is that *desideratum* which, if supplied, would bring with it the solution of the whole biological problem, since it would be a state enjoying real existence up to the very moment of transition from non-living to living matter, the very moment in which life originates, the moment of what is known as spontaneous generation, *generatio æquivoca*, or *abiogenesis*. Now one and the same piece

of protoplasm is a very different thing, according as it is dead or living. Dead, its energies are simply chemical; living, they are something more. They are vital functions. The second question, then, is,—On what does this *more* depend? We want in answer to it, not a term or phrase descriptive of vital functions, such for instance as that used above in speaking of stability founded on differentiation, grouping, and interaction of elements, but their real condition, whether this be looked for in or beyond the structure performing them.

Some words from an old but still highly honoured authority, Johannes Müller, illustrious *inter alia* for his discovery of the great fact or law known as that of the "specific energy of the senses," will perhaps best serve to bring the problem clearly before us: "The matter forming organic bodies has a constant tendency to undergo decomposition; it is only the continuance of life which preserves it. . . . Organic matter is thus annihilated, and with it the organised being of which it formed part; and in ceasing to present the phenomena of life, it falls under the influence of those laws which govern the formation of chemical compounds. . . . Chemical compounds, we know, are regulated by the intrinsic properties and the elective affinity of the substances uniting to form them; in organic bodies, on the contrary, the power which induces and maintains the combination of their elements does not consist in the intrinsic properties of these elements, but something else, which not only counteracts their affinities, but effects combinations comformably to the laws of its

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operation. Light, heat, and electricity, it is true, influence the compositions and decompositions going on in organic bodies, as they do those in inorganic bodies; but nothing justifies us in regarding without further inquiry any one of the imponderables,—heat, light, and electricity,—as the ultimate cause of vital actions."[1]

As a merely denotative or designative definition of life, nothing, it seems to me, can be better or more luminous than the famous one given by Bichat: "On cherche dans des considérations abstraites la définition de la vie; on la trouvera, je crois, dans cet aperçu général: la vie est l'ensemble des fonctions qui résistent à la mort."[2] If by death, *la mort*, we understand him to mean the simply chemical actions performed by structures which have once exercised, or have been capable of exercising, the double action, *ad intra* and *ad extra*, which is called *life*, this definition precisely states what phenomenon it is, the real condition of which is sought by biology. If, on the other hand, it is taken as a real and final definition of life, a definition showing its possibility as well as its nature, then it is obvious that it throws us back on the obscurer question,—what is death? Inorganic matter is not the same thing as dead matter; even its *inertia* is force; it is only matter which has once lived in organic structures that can ever be or become dead; namely, when its life has ceased. To attempt a definition of the real nature of life by contrasting it with death, which pre-supposes it,

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[1] *Elements of Physiology.* Dr. Baly's translation. Prolegomena. Vol. I., p. 4. 2nd Edition. 1839.

[2] *Recherches Physiologiques sur la Vie et la Mort.* Article I.

would clearly be to expect the cart to draw the horse, instead of *vice versa.* Bichat can hardly have intended his *aperçu général* in this sense.

Auguste Comte, however, has maintained that Bichat, from being under the influence of an "ancient philosophy," made choice of "the chimerical strife" between "dead nature and living nature" as the "essential character of life."[3] It would be out of place here to discuss Bichat's real meaning; but perhaps no better way could be chosen to exhibit the true nature of the main question of biology, than to quote the immediate sequel of these words, in which Comte gives his own conception of life:

"La profonde irrationnalité d'une telle conception" [the one which he has attributed to Bichat] "consiste surtout en ce qu' elle supprime entièrement l'un des deux eléménts inséparables dont l'harmonie constitue nécessairement l'idée générale de *vie.* Cette idée suppose, en effet, non seulement celle d'un être organisé de manière à comporter l'état vital, mais aussi celle, non moins indispensable, d'un certain ensemble d'influences extérieures propres à son accomplissement. Une telle harmonie entre l'être vivant et le *milieu* correspondant caractérise évidemment la condition fondamentale de la vie."[4]

This passage, by pointedly bringing forward the environment as an essential condition, serves admirably to set the main question of biology in its true light. There is (1) the organised being

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[3] *Cours de Philosophie Positive.* Ed. Littré. 1864. 40me Leçon. Vol. III., p. 200.

[4] *Ibidem,* p. 200—1.

capable of living; there is (2) the environment, the *milieu* as Comte calls it; and there is (3) the function of living, of which the harmony between the other two is the fundamental condition. Now what is meant by *life* in biology, or rather, which of these three things does biology seek? Clearly it seeks to explain the third, the function of living, by connecting it with the first, the constitution of the organised being which is the seat of life, though always in connection with the second, the environment. So that the first is what it is really in search of, this being the factor which still remains unknown; and this in one word is *Vitality*, or that constitution of the organised being which, in a suitable environment, renders it capable of living.

For if we say, with Comte, that it seeks to explain life as the function of living, by referring it to the harmony between the constitution of organisms and their evironment, as its fundamental condition, we are occupied with what is a preliminary only, a preliminary which discloses a further question concerning the harmony itself. Before a harmony can be appealed to as an understood fact, the terms between which it exists must be independently known. And therefore the real question, which immediately arises, is this,—How comes the capacity for living to make its appearance in organisms; or, how come structures, which are capable of living in a suitable environment, to exist? Of the two remaining features, the two terms or factors of the harmony, this is the new one; the environment belongs wholly to physics and chemistry; it is the special constitution of certain chemical structures, whereby they become

capable of that special interaction with the environment called *living*, which biology seeks to discover, and which, if discovered, would give us the explanation of life, in the sense of the function of living.—Suppose that a harmony between an organised being and its environment does "characterise the fundamental condition of life," there still remains the question, what specific difference in chemical structures, or what specific change in the energies they display, makes them into organised beings in the proper sense of that term, and so brings them into that specific harmony with the environment which characterises life, the environment remaining the same, whether the structures are organised or not, whether they are chemical structures only or vitalised structures besides.

Thus Claude Bernard writes: "La vie a son essence primitive dans la force de développement organique, force qui constituait la nature médicatrice d'Hippocrate et l'*archeus faber* de van Helmont. Mais, quelle que soit l'idée que l'on ait de la nature de cette force, elle se manifeste toujours concurremment et parallèlement avec des conditions physico-chimiques propres aux phénomènes vitaux."[5]

In short, what biology seeks as its first and fundamental truth, which can alone supply a basis for its particular truths of all orders, and alone establish it as a science organised on a strictly analytic foundation, is a knowledge of the real condition of vital energies, so far as that condition is an inherent

[5] *Introduction à l'étude de la Médecine Expérimentale.* 2me Partie. Chap. II., § 1, p. 161. Edit. 1865.

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property of the organic structures which exhibit them. And this enquiry, however we may name the real condition which is its special object, cannot in my opinion be regarded as hopeless or chimerical. The connection of living organisms with chemical structures is too close, and at the same time the difference between vital energies on the one hand and chemical and physical energies on the other too marked, to permit us ever to acquiesce in regarding the existence of organisms, living or capable of living, as an ultimate fact incapable of explanatory analysis, taking this question quite apart from that of their genesis, or time of their first appearance as real existents. True, it has not hitherto been explained, but it is not on that account an ultimate datum of explanation, as Comte among others is content to take it, thereby shelving the question of what constitutes the *differentia* of living organisms.

Without venturing on any speculative conjecture as to the peculiar nature of this *differentia*, it may farther be remarked, that there is neither need nor justification for travelling in search of an hypothesis beyond the circle of conceptions already familiar to science, nor can there be, until such time as that circle of conceptions shall have been explored without positive result. The change from chemical to vital energy is the appearance in a new shape of what we are already familiar with as the storage and expenditure of energy, its storage as potential, its expenditure as kinetic. The alternation between these two forms of energy, when they appear as vitality, takes place indeed on a higher platform than the simply mechanical, physical, and chemical

platforms, on which we have hitherto been considering it, and on which we had no other *prius* to which to refer it, than the *vis insita* or *vis inertiæ*, in all matter simply as such. And this *prius* remains unaltered, whatever may be the forms assumed by the potential and kinetic energies which mediately or immediately depend upon it. Chemical energies displayed by chemical structures, which are of different kinds depending on intrinsic differences of substance and structure, are the platform or pre-supposition of vitality; but the change from these chemical structures and energies to vital structures and vital energies is a change which does no more than introduce again, in a new shape, the same phenomenon of storage and expenditure. This change may be described as follows. The structures become permanent for a certain life-period, and the manifestation of their energies becomes recurrent, until the structures which store them have expended that store of self-renewing energy which renders them permanent.

In one way, it is true, there is more than this. There is not permanence only. During the first part of the natural or normal life-time of an individual organism, that is, from its origin to its maturity, there is not only permanence of structure, but increase in bulk of substance, and corresponding energy; and not only increase of the structure in bulk and energy, but also a certain development of it, or differentiation of its parts, which is the basis of a differentiation of its functions, both *inter se* and in interaction with its environment. There is, during the first part of life at any

rate, not only a storage of substance and of energy; there is also a development and differentiation of the organism, which can only be called properly a *storage of structure;* every part of the structure stored being also itself a store of energy, and a seat of function.

A living organism is one which normally, and supposing a suitable environment, goes through a series of changes, depending on the expenditure of energy stored and inherent in itself at the beginning of the process; a series characterisable as increase, development, differentiation, maturity, decline, and cessation, of its inherent energies; to be a living organism is to have a life-time, however short; and the sequence of these energies, the order in which they accompany and follow each other, must in some way or other depend upon the way in which they are originally stored in the organism, that is, upon the configuration of the structure which stores them, previously to their display in the life-time of that structure as a living organism.

The question, then, for biology really is,—How can we conceive in a manner capable of verification, or at any rate of confirmation, by experiment and observation, a storage of structure taking place? It would seem to involve, in its very earliest and simplest stage, a collocation, or as it were a stratification, of complex chemical structures, upon or by the side of one another, no one of which is capable as a whole of combining with another as a whole, that is, with the loss of the properties of either, as in the case of strictly chemical combinations; while at the same time the structures in

question, or some of them, must be capable of absorbing without loss of their own structure, that is, of assimilating and incorporating with themselves, substances belonging to their organised or unorganised environment, so adding them, as it were, either immediately each to its own fund, or mediately to that of the other structures composing the organic union. The total fund of energies of the chemical structures composing the union would then become the fund of energy with which the life of the first or lowest organism would begin. And its life would normally last until that fund of energy was expended; reproduction of its similars being either an incident during its life-time, or else the termination of it, as in the case of reproduction by fission. The course of the life-history of the individual organism would thus be determined principally by the partial interchange of chemical energies between the several complex chemical structures, of which the organism was originally composed. Of course a conception of this kind is but preliminary to the further question, What conditions in the inorganic world can be conceived as probably conducing to such an original collocation or union of complex chemical structures into a single comparatively permanent organism?

In elucidation of this conception I would refer to what was said in the foregoing Section on the subject of absorption of nutriment, as the first and most essential step in the vital process of metabolism. It is also the step in which the contrast with strictly chemical combination is most clearly visible. For in vital absorption of nutriment, the combination of substances, which takes place in

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the organism, is not one in which the properties of the combining substances wholly disappear, to be replaced by a new substance, with wholly different properties, but is a combination entirely to the advantage of one of the contributories, namely, the absorbent structure, which converts the other into a substance like its own, while incorporating it therewith. The absorbed structure perishes as a structure, the absorbent grows, both as a structure as in point of mass. It is, so to speak, a one-sided chemical union that takes place. The process may be called the first and lowest instance of automatism on the part of living substance. But the great question is, what specific chemical structures are capable of exercising this automatic and assimilative energy.

Now, without venturing to adopt any hypothesis or theory in regard to this question, it may be remarked, that we have a somewhat analogous case to this on a lower platform, a case of accretive action in inorganic substances, in the processes of crystallisation; processes whereby solutions of various substances, and even comparatively simple substances like water, on passing from the liquid to the solid state, assume a definite crystalline structure, and in which the solid, when once formed, continues to add layer upon layer to its own substance, thus increasing the bulk of its own structure, at the expense of the liquid, or solution, out of which it is itself formed. Readers of the works of the late Professor Tyndall will remember how frequently he recurs to the idea, that crystallisation is the first and simplest effort of Nature in the development and organisation of her structural energies.

The part which crystalline formations are known to play in the animal economy is a very large one, as may be seen from Dr. Sheridan Lea's Appendix, already quoted, *On the Chemical Basis of the Animal Body.*[6] It has also been made the foundation of a theory of life by Herr C. von Nägeli, by means of his well-known hypothesis of *micellæ*, a theory which covers the whole ground of biology, that is, both the vegetable and animal kingdoms.[7]—Again, referring to a work already quoted, we read as follows: "Neither liquids nor gases present the least trace of structure. They cannot even support their own weight, much less sustain any longitudinal or shearing stress. A solid on the other hand has both tenacity and structure, and resists, with greater or less energy, any force tending to alter its form, as well as change its volume. The tenacity and peculiar forms of elasticity which solids exhibit are characteristics which are familiar to every one, but the evidences of structure are not so conspicuous. The structure of solids is most frequently manifested by their crystalline form, and this form is one of the most marked features of the solid state."[8] Again, a little farther on, "All the mineral substances of which the rocks of our globe consist have a crystalline structure, and are aggregates of minute crystals like the arborescent forms" of *sal ammoniac*, for instance, among others, the growth of which the writer had just been exhibiting.[9]

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[6] Appendix to Professor Michael Foster's *Text Book of Physiology.* 5th edition.

[7] *Mechanisch-Physiologische Theorie der Abstammungslehre*,—von C. Von Nägeli. München und Leipzig, 1884.

[8] *The New Chemistry*, above cited, p. 51.

[9] *Ibidem*, p. 53.

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Crystals, it seems, make their way into our old acquaintance, the amœba. We have already seen that it is dependent upon the vegetable world for the protein which its protoplasm contains. The same authority tells us, that "crystals are generally to be met with in the cell protoplasm" [of the amœba], "but of their origin and significance nothing is at present known."[10] In the case of *Spirogyra*, however, a member of the vegetable kingdom, we find crystals of protein, which seem to perform important functions. "At intervals along each chromatophore" [that is, each of the green spiral bands of which the plant consists] "round bodies will be observed which appear green like the rest of the band, but on careful examination are each found to contain a small colourless mass of proteid substance, termed the *pyrenoid*. This pyrenoid is of a crystalline form, usually appearing hexagonal in optical section, and can be brought out more clearly by the use of staining reagents. Bodies of this nature are of very general occurrence in the chromatophores of the Algæ. It is only around the pyrenoids that starch is formed, and if the plant has been exposed to the light before examination, the pyrenoid will be found surrounded by a layer of small starch grains often present in so great a mass that the band is distinctly swollen at the places where they occur."[11]—Again, as to other instances of this phenomena, "It will be remembered that the starch-grains are formed around the pyrenoids.

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[10] Professors Huxley and Martin. *Elementary and Practical Biology.* Chap. VIII., p. 372.

[11] *Ibidem.* Chap. XI., p. 398.

As regards the part played by the latter in the process we have no definite knowledge at present, but similar proteid crystalloids are found elsewhere in connection with starch-forming corpuscles." [12]

But in speaking of crystallisation as found in living organisms, it must be remembered, that in all cases of the building up of protoplasm by the agency of the living matter itself,—whether crystalline bodies are present or not, and whether crystallisation has or has not anything to do with it, on which point I do not profess to be able to form an opinion,—"the addition of molecules to those which already exist takes place not at the surface of the living mass, but by interposition between the existing molecules of the latter." [13] And again, in all cases of growth, "the increase of size which constitutes growth is the result of intus-susception, and therefore differs altogether from the growth by accretion, which may be observed in crystals and is effected purely by the external addition of new matter."[14] This, then, seems to be a general law of growth in living bodies, to which the part played in that growth by crystals, if any, would have to conform. And such seems also to be the view taken by Von Nägeli in his micellar theory.[15] On this whole subject I would refer in addition to Professor W. R. Macnab's article on Vegetable Histology, in the

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[12] *Ibidem*, p. 402.

[13] From the article *Biology*, by the late Professor T. W. Huxley and W. T. Thiselton Dyer, F.R.S., in the Encyclop. Britannica, Ninth Edition. Vol. III., p. 679.

[14] *Ibidem.*

[15] *Abstammungslehre*, already cited. See pp. 35, 78, 96, 114, 170, 177, and the Summary.

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Encyclopædia Britannica, where a brief account of Von Nägeli's theory will also be found.[16]

The foregoing considerations are not intended to do more than indicate a direction in which the discovery has been attempted, and may yet possibly be achieved, of the mode of derivation of living organisms and vital functions from unorganised structures and their energies, without sacrificing anything of the peculiar characteristics of the former, that is to say, their automatic action or action *ab intra*, or overlooking the fact, that they continue to undergo changes of structure and function during a life-time, without losing their identity as living organisms. Vital energy, even though it should turn out to be derivative and not primary, must in any case be regarded as a distinctively new or special form of energy, an organic energy or *nisus*, belonging to and inherent in a new or special form of material substance, which for that reason we call living substance or organism. It is, as it were, the *vis insita* of those organisms; by which I mean, not that it is not an energy, but that, though an energy, it stands to the complex structures which possess and exert it in a relation analogous to that which *vis insita* holds with regard to every particle of matter simply as material. Vitality is energy, inasmuch as the structures which possess it are already complex chemical structures, or masses of substance which its presence constitutes living substance or protoplasm; the specific mode or nature of which combination, or original formation

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16 Encyclop. Brit. Ninth Edit. sub voce *Histology*. Vol. XII., pp. 12 and 13.

of living structures, that is, of organisms endowed with vitality, is what biology seeks first and foremost to explain, by discovering its real condition or conditions, that is to say, the special nature of the circumstances which lead up to it.

Nor can I think, that reasoning like the foregoing, based upon what is at present positively known of the structure and behaviour of vegetable and animal organisms, is in the least invalidated by the proof which has been given, that no cases of abiogenesis have ever been observed, or the fact that all the many experiments, devised in order to demonstrate it, have turned out failures. I allude to the late Professor Tyndall's well-known article on *Spontaneous Generation*.[17] The air may teem, as he is doubtless right in saying that it does teem, with myriads of microscopic infusoria, myriads of minute living beings, to the presence and activity of which the putrefaction of animal and vegetable substances, and the contagia of various deadly diseases may be due.

Still this does not show, that these teeming myriads do not ultimately derive their being from unorganised matter, but require the supposition of some form of living matter, as an ultimate mode of physical existence.[18] This it would seem is the alternative before us, and it is an alternative which the evidence at our command is not sufficient conclusively to decide. On the one hand there is the repeated failure of all attempts to trace life back

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17 Reprinted in his *Fragments of Science*. Longmans. Vol. II. See also his general summary of the question in his famous Belfast Address, reprinted in the same Vol.

18 See on this point the late Professor Huxley's article *Biology* already cited. Encyclop. Brit. Vol. III., p. 689. I think I am right in saying that it is to Huxley we owe the term *Abiogenesis*, among several other terms, *Agnostic* for instance, equally valuable and expressive.

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to an origin in non-living matter and non-vital energies; on the other hand there is our inability to conceive the nature of life without supposing the prior existence of certain physical and chemical substances and energies, as the material, vehicle, or condition of it.

The question is, Are life and living matter original forms of physical existence, side by side with the chemical elementary substances and energies, and with the etherial substance and the energies which it displays, or are they to be regarded as derivatives and modifications of them? Either hypothesis would seem to be legitimate. It is merely a question of the preponderance of evidence. Neither of them leads us to travel beyond the circle of ideas which are derived from known facts, and constitute the sufficient foundation of positive science. If living matter is accepted as an ultimate and inexplicable mode of physical existence, this is no more than must also be said of ponderable matter which, acting in masses and taken apart from intrinsic differences of quality, displays mechanical energies; of the seventy or more elementary substances of chemistry (also ponderable) displaying chemical affinities or energies; and of etherial matter displaying electric and magnetic energies. It is the closeness of the union between chemical and vital structures and energies, as seen in living organisms, together with the fact that we know the chemical existing independently of the vital, but never the vital independently of the chemical, which irresistibly suggests the possibility of detecting analytically the nature of the *nexus* between them. On which

being done, the probability of a generation of the vital from the chemical taking place, or having taken place, at some epoch or epochs of time, that is to say, the probability of the fact of *abiogenesis*, would be enormously increased. For its *possibility* at any time would thereby have been established.

But there is another hypothesis, or rather class of hypotheses, very different from either of the alternatives just spoken of, and differing from them in the very point of leading us beyond the circle of ideas derived from known facts, and capable of forming the foundation of positive science. This class of hypotheses involves us at once in conceptions of a wholly different order.

The main conception common to all of them is, that there lies hid in living substance or protoplasm some real agent which is not physical or chemical matter of any kind whatever, but has organising power or vitality as its own inherent characteristic; in other words, the conception of an Immaterial Soul. Supposing this conception adopted, the fact of vitality in organisms would then be held to have been accounted for, simply by referring it to a special agent as its real condition, an agent conceived both as inhabiting material organisms, though not itself material, and as endowing them with its own inherent vitality, so long as it continued to inhabit them. If such an active immaterial agent, or the abstract vitality which is its agency, could be positively brought before the mind, or made positively conceivable,—as *vis insita* and space occupancy, evidenced by sense, can be made positively conceivable as inseparable elements constituting concrete matter, but

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incapable of a separate existence,—then no doubt it would offer a valuable alternative hypothesis, subject of course to verification, in accounting for the phenomena of life, in the present imperfect state of our knowledge. The difficulty lies in framing the conception; and this requirement is a *sine quâ non* condition of its being entertained as a scientific hypothesis.

Now neither the conception of an immaterial living agent, nor the still more abstract conception of the vitality which is its agency, can be distinctly framed in thought. These are not positive conceptions at all, but empty words to which no positive meaning, consistent with experience, can be attached. This, however, does not prevent the adoption of the former, the conception of an immaterial agent having life as its agency, by Scholasticism, as most consonant to the theology of the Church of Rome. It was adopted as the foundation of a theory in the heyday of Scholasticism by St. Thomas (Aquinas), who derived it from Aristotle. The well-known definition of the Soul given by Aristotle is as follows: "The first entelechy of a physical organic body, that body having the potentiality of life."[19] By *entelechy* is meant the actuality or completeness of anything; the term is sometimes rendered into English as *act*, Latin *actus*; and like the term *energy* (ἐνέργεια) is opposed by Aristotle to potentiality (δύναμις), as

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[19] Aristotle, *De Anima*. Book II. Cap. 1. διὸ ψυχή ἐστιν ἐντελέχεια ἡ πρώτη σώματος φυσικοῦ δυνάμει ζωὴν ἔχοντος. τοιοῦτο δέ, ὃ ἂν ᾖ ὀργανικόν. —Page 412a, line 27.– A full and systematic account of St. Thomas's psychology, with references to his text, followed by a careful criticism, will be found in Herr Professor J. Frohschammer's work, *Die Lehre des Thomas von Aquino kritisch gewürdigt*. Leipzig, 1889, pp. 349 to 434. This work of Frohschammer's is invaluable as an exposition of the nature and methods of Scholasticism, and should be familiar to every student of Philosophy.

in the present case. It expresses statically what ἐνέργεια expresses dynamically. And the meaning of the definition in plain terms is, that the soul is the "form" (εἶδος), or "formal cause" (οὐσία), in virtue of receiving which the formless, or relatively formless, matter, which receives it, becomes an actually living organism. In the body actually living, you really have the soul actually operating; or, the essence of the living body, *qua* living, is the soul.[20]

Now in this definition there is an ambiguity which, do what I will, I have never been able to reduce to simplicity. Is it meant that the soul *is* the actuality of the living body, or that it is the *source* of that actuality? Is it the living body itself in its first actual stage of life, or is it the essence, form, or formal cause, of the body's actual life? I will not undertake to decide. Nor is it needful. For in either case it is a mere "that which" definition; that is to say, a definition which gives back a description of the thing to be explained, as if it were a description of the thing which is called in to explain it; as we find, for instance, in the case of another definition of the Soul, which Dr. Gildea quotes from Aristotle, in the paper just cited (p. 75), "the soul is 'that by

[20] See a compendious but extremely able exposition and defence of the Scholastic doctrine in a paper by the Rev. W. L. Gildea, D.D., *On the meaning of Life*, in the Proceedings of the Aristotelian Society, Vol. II. No. 1. Part 2. Williams and Norgate. 1892. Able as it is, the paper entirely fails to carry conviction. Indeed at one place it involuntarily betrays the futility of the theory which it defends, in saying (p. 74): "To define the soul, then, the act of an organic body, is to explain the soul by the formal effects which it produces in its proper subject."—Precisely so. But this is just the reverse of what is required. It is required to explain the experientially known effects by an independently formed idea of the nature of the soul, not to explain the nature of the soul by the effects which it is supposed to produce. Now no positive idea of the nature of the soul, arrived at independently of its supposed effects, is contained in the theory; nothing but a statement in general terms,—"first entelechy, etc.,"—of the relation which it is supposed to hold to the body.

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which we primarily live and have sensation and move and understand.'" The something called *Soul* is brought in to explain how it is that bodies live. What, then, is the Soul?

Taking the first of the two possible meanings, —*the soul is the actually living body*,—this is merely naming the actually living body a *soul;* no light is thereby thrown upon the question, How bodies come to live, or to be souls. Take the second meaning,—*the soul is the source of life to the body ;* —again it is the same ; no light is thrown upon *what* that source is; we have merely named the source of life *soul.*

The definition in short is a mere verbal juggle, perfectly pardonable in Aristotle and in St. Thomas, who both of them started with a fixed traditional and unhesitating belief in the real existence of Souls, a belief, it may be added, belonging to the common-sense or pre-philosophic order of ideas, and did their best to render their ideas of those realities intelligible; but absolutely worthless as formulating a scientific conception. The name has literally no positive conception behind it, and therefore cannot serve as the basis of a scientific theory.

What Aristotle's definition really did, and that in which its fallacy consisted, was this : it took one of the two inseparable elements of living organisms, namely, their energy, the other element being the matter in which the energy is inherent, and by which it is displayed, and elevated it into an independent existent, the proximate real condition of life, thus making an entity out of an abstraction.

It only now remains to notice the immense difference which arises, both as regards the nature of Biology, and as regards the position which it occupies relatively to the other positive sciences, according as we base it upon any materialistic hypothesis concerning the nature and origin of life, or upon any immaterialistic hypothesis, such as that of Aristotle and Scholasticism, which has just been criticised. In the former case, biology becomes the last and highest link in the single connected chain of the purely physical, analytical, and positive sciences. In the latter case, it is cut off from those sciences, and made to stand on a basis of its own, a basis entirely *sui generis*, not positively conceivable, and therefore consisting of words representing nothing but unverifiable fancies. It thereby ceases, in fact, to be a science at all. A theory of this kind must be a broken reed for any Theology to lean on. **Book II. Ch. II. § 4. Biology.**

§ 5. Before touching on the next branch of our subject, Natural History, a few words must be said on the distinction between the analytical and the historical departments of science generally. All the sciences hitherto spoken of belong to the analytical department, that is, they treat their phenomena analytically. It is in this department, that is, by analysis, and inferences resting ultimately on analysis, of the phenomena concerned, that all general laws are discovered, whether the phenomena are taken as simultaneous, taken as consecutive, or taken as both at once, and whether accordingly the laws discovered are laws of co-existence, or sequence, or both. In other words, all science rests ultimately on analysis of phenomena as its foundation. **§ 5. Natural History.**

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When, however, we have arrived by these means at the discrimination or determination of concrete existents, or classes of existents, of any particular kind, or at groups of existents which are more or less permanent, whether the existents composing them belong to the same or to different classes, as for instance, the sun and the planets in the solar system, or the tissues and organs composing a living organism,—all such concrete existents may be considered in their actual course of existence, different for every one of them, and individual as they are individual; that is to say, their genesis and history may be traced. The history of anything is the sequence of the co-existences which compose it, at successive moments, and from moment to moment, in time. The synthesis of all such individual existents and groups of existents is the work of Nature; the scientific knowledge of them by man begins with analysis, and proceeds, when individuals or groups have once been determined, to the history of those groups or individuals.

There is no such thing as a general law of the history of any individual existent, or individual group of existents, simply as history. Such a law, supposing it possible, would be a Fate or Destiny. The genesis and history of every individual are unique; they occur once and never again. The Universe itself can be no exception, so far as its history is concerned; and genesis it has none. In the material world, the general laws by which the genesis and history of any given individual existent, or group of existents, considered as forming a single series of events, are governed,—an expression which does not imply that laws, which are

merely statements of generalised facts, have any coercive or efficient power,—are laws which apply to the genesis and history of other individuals and other groups, as well as to theirs. And all these laws, being general, for without generality there is no law, are laws discovered in some one or more of the analytical departments of science. That is to say, they are statements of the modes in which the several kinds of matter, together with the several kinds of energy which they display, are found to act in conjunction with different groups of other kinds of matter including their energies, and according to the different proportions in which the several kinds of matter and energy concerned may be present.

It is in these energies of matter, that is, ultimately, in the different modes of Force which constitute different kinds of matter, that the real agency lies which is commonly called causative agency or Causality. Not that even here we come upon any occult or transcendental agency, or any agency whatever, beyond the mere fact that *this* occurs *after this* and *with that*, and except *after this* and *with that* does not occur at all; but that in these modes of Force, Matter, and Energy, and in these alone, those phenomena are found to consist, upon which phenomena of all kinds, whether of their own kind or of any other, are found to depend for their coming into, continuance in, and disappearance from the existential order; a difference in virtue of which we class those first mentioned phenomena apart, not as Causes, but as Real Conditions mutually conditioning one another, or as Real Conditions as well as Real Conditionates,

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phenomena of all other kinds being classed as Real Conditionates only.

Now in the history of anything, apart from these modes of Force, Energy, and Matter, which constitute real conditions, and their reciprocal activities, there is no causal or really-conditioning agency whatever. The time-duration occupied by the reciprocal activities of any portion of matter, or any group of such portions, is one and the same with the time-duration which the history of that portion or group of portions occupies. Consequently the order of sequence in which the several distinguishable states of any such portion or group of portions succeed one another is a conditionate of those reciprocal activities, not itself a real condition; neither is any former state in itself a real condition of the next or any subsequent state, the name used in so speaking of it being in truth nothing more than a brief or compendious expression for the reciprocal activities of which it consists. From which it follows, that the genesis or history of an individual existent or group of individual existents, be it of what nature it may, is fully explained, when it is brought under, or shown to be a case of, some one or more of those general and analytically discovered uniformities in the reciprocal activities of physical agents, which man anthropomorphically conceives as *Laws of Nature.* Such explanation and subsumption in the case of history or genesis may properly be called scientific construction or synthesis.

Now every concrete individual existent has a genesis and a history—an atom, a molecule, a pebble on the beach, a leaf on a tree, a single

organic cell, an organism, a family, a society or community, a planet, the population of a planet, a solar system, the whole material world. And what is true of one is true of every one, namely, that its genesis and history are unique, and that the general laws to which these are subject must be discovered, if at all, by first bringing them into comparison with the genesis and history of other existents, and then referring the similar events so arrived at to similar sets of real conditions; which can only be done by analysis, not only of the structure and energies of the existent itself, and of the other existents to which it is compared, but also of the environment and circumstances under which they have existed.

This it is more or less possible to do in the case of every individual or group of individuals, with one single exception, that exception being the material world, or material part of the universe itself. All general laws, which are known or knowable by positive science, are drawn from phenomena within and not beyond the material world. So far as our positive knowledge goes, the life-history of the material world as a whole is not subject to any positively known law of Nature, general in the sense of being exemplified in other worlds also, though, at the same time, it is also impossible to conceive, that it is not included under some general laws, not positively knowable by us, along with other realities or real existents which, with their laws, are also wholly unknown to us by any positively knowable characteristics. A general law of the Evolution of the material world, in this use of the term *general*, is therefore for man an impossibility.

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What is called the Theory of Evolution begins by assuming some primitive state of the whole of the matter and force composing the material world, and proceeds to bring the subsequent history of that state under general laws derived from the observation of matter and force, as displayed in the different classes of substances and energies within the material world itself. In other words, it attempts to discover the life-history of the material world, by referring it, not to laws supposed to be common to it with other imaginary extramundane systems, but to laws discovered, by analysis and inferences based on it, in the various analytical departments of physical science, and applicable to different portions or sections of its own course; the principle employed in this application being that known as the Uniformity of Nature, namely, that similar conditions have similar results, whenever and wherever they occur in the Course of Nature.

Any theory of Evolution must necessarily assume an initial state by hypothesis. And the hypothesis most generally accepted as applicable to our material world is an extension, to the whole material world, of what is known as the Nebular Hypothesis or Theory of Kant and Laplace, concerning the origin of our Solar System. It may be said to cover the whole ground of inorganic and non-living matter, and to be capable of extension over organic and living matter, so as to join hands with the Evolution of the more complex from the less complex forms of life, which in that domain may be taken as already established, in case the fact of abiogenesis should ever be demonstrated.

As matters stand at present, the independent origin of Life makes an unbridged gap in that continuous development of the material world, taken as a single complex existent, which any Theory of Evolution requires.

What is commonly understood as the Theory of Evolution, either as applied to the solar system only, or extended to the whole material world, proceeds on the hypothesis, that the simplest and least differentiated form or forms of Matter were also the earliest, or first to come into existence, in historical order. But since nothing is positively known of the nature of the real conditions which brought Matter into existence originally, or which continue to sustain it, this hypothesis, not being immediately evident, is one which admits of alternatives. It is conceivable, for instance, as already stated in the preceding Section, that organic living matter was the first to exist historically, possibly in the shape of a being or beings which baffle our powers of imagination, part feeding on part, or one being feeding on another, and endowed with modes of consciousness equally unimaginable by mankind. The whole of what we now call inorganic matter may conceivably have been formed and deposited in space as a detritus or waste product of their organic activities. The whole of the organic world, as at present known to us, may similarly be, as it were, the relics of that primordial living matter, now reduced to live upon, and struggle with, the vast accumulations of inorganic matter deposited in the course of ages by their own organic progenitors. This hypothesis would involve reversing the direction of the Course of Nature, as it is conceived by

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the Theory of Evolution commonly accepted, and writing, as it were, its history backwards. Then, too, the world of now living beings must be regarded as engaged in a hopeless struggle, so far as their collective life in presence of inorganic matter is concerned, with the ever more and more preponderating accumulations of inorganic matter, and moreover of inorganic matter tending finally to assume its simplest form of an homogeneous aggregation, the seat of purely mechanical energies in equilibrium.

But it would be beside my purpose to discuss either the accepted or any other form of the Evolution Theory, or to dwell farther on the relations which any of them may suppose to exist between the organic and inorganic kingdoms. In particular, I must abstain from criticising, at least on its scientific side, concerning which I have no right to speak, the comprehensive theory of Mr. Herbert Spencer, with whose name the doctrine of Evolution is indissolubly associated, and to whom all genuine and independent thought is so deeply indebted. I mean his theory of an endless series of alternate eras of evolution and dissolution of the material world; a theory based ultimately upon what he calls the "Persistence of Force," and the inferences which it involves, including the result, that "the Force which the Universe presents falls into the same category with its Space and Time, as admitting of no limitation in thought."[1]

But some few words must necessarily be said on the philosophical side of this theory, and its

[1] See his *First Principles*. Third Edition. 1870. Part II. Chapter XXIV. § 190. pp. 550—551.

remarkable philosophical result. In the first place, this alternating process of evolution and dissolution can only be conceived as strictly unlimited in time, both *a parte ante* and *a parte post*, that is, as eternal, by first conceiving persistent force as identical with the Unknowable and Unconditioned Reality, upon which the existence of the material world depends. But this identification is a contradiction in terms, inasmuch as a persistent force has a definite meaning and a positively known reality. It therefore involves a conception of persistent force very different from that which I have been led to frame, and have endeavoured to exhibit. With me *force* means persistent force, in the sense of continuing for some time-duration, and is one essential co-element, spatial extension in three dimensions being the other, of real Matter, which is also persistent, and with which it is co-eval, though neither force nor matter is eternal, at least *a parte ante.*

The reasoning by which Mr. Spencer arrives at the identification of his eternally persistent force with his Unknowable and Unconditioned Reality may be seen by comparing Part II., Chap. III., § 50, p. 169, of the work just cited, with Part II., Chap. VI., § 60, p. 189, of the same work. In the former of these passages he represents force as being immediately experienced in sense-perception, and this experience he speaks of as the ultimate experience, from which all other kinds of experience are derived. In the latter passage he maintains, that our experiences of force, being intermittent, do not make it known to us as persistent force. When we assert the persistence of force,

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the force of which we assert it is not force as we know it, but force as it exists out of our consciousness. Its persistence is "the persistence of some Power which transcends our knowledge and conception." "Asserting the persistence of Force," he says, "is but another mode of asserting an Unconditioned Reality, without beginning or end."

There is surely a great confusion of thought in the doctrine which these passages contain, and contain severally, as well as in comparison with each other, though it is by comparing them that the confusion can be most readily brought to light. Are we to suppose Mr. Spencer to be speaking of one kind of force only, the phenomenal, or of two, the phenomenal and the noumenal? Either supposition is fatal to the consistency of the doctrine. If the phenomenal kind of force only is spoken of, how can a kind of force which is known by actual experience become unknown simply by being thought of as persistent, even though it be by a necessity of thought that we so think of it? If two kinds, phenomenal and noumenal, are spoken of, how can that kind, which is distinguished from the other by the fact of our having no actual experience of it, be thought of as force at all, to say nothing of its being thought of as persistent? It can only be in virtue of some *a priori* dogma or other, such as that of the cause being of like nature to the effect, or the noumenal reality of like nature to its phenomenal manifestation; and this is in fact the footing upon which Mr. Spencer himself rests his conception, though of course not avowedly, in calling it a postulate, and maintaining that it is the one ultimate truth, transcending

demonstration, of which all other truths are derivatives, as in § 59, p. 188—9, of the work cited.

The same common-sense fiction which played such havoc with Kantianism, the fiction of a noumenal reality, unknowable in itself, but manifesting itself in the phenomena of experience, a reality of which, in the case of force, "we are indefinitely conscious as the necessary correlate of the force we know" (p. 189), is thus the basis of the whole Spencerian doctrine of Evolution. It is the so-called *Thing-in-itself* fallacy, long ago detected. It consists, to express it once more in terms which will be familiar to readers of the present work, in hypostasising the character of being a real condition, apart from the fact of standing in the known relations which we so characterise, and in thereby raising that abstract character, conception, or term "of second intention," to the rank of a real but unknowable existent.

But how, it must be asked, can such a confusion have actually originated? Here the truth seems to be, that Mr. Spencer's supposed unknown force is really known force, but first enters into our knowledge, not as an ultimate datum of experience, but as a result of thought dealing with ultimate experiences; and is therefore always thought of as an element in real material objects, and never thought of save as persistent, in the sense of existing continuously for some time-duration. So far from being unknown, it is known as an essential element in the positively known material world. It is no more unknown or unknowable than the material objects, in which it is an essential and inseparable element, and our knowledge of which

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is also a result of thought and inference from data immediately experienced. Mr. Spencer's unknowable persistent force is therefore a chimæra.

But what of his known force, that of which we have actual experience? This must be pronounced a chimæra also. He speaks, we have seen, of our having experiences of force which are the ultimate source of all our other experiences, "this undecomposable mode of consciousness into which all other modes may be decomposed" (p. 170). Now, it may safely be said, there are no such experiences of force. Mr. Spencer himself broadly distinguishes experience from that which causes it; but this being done, he fails to draw the further distinction between ultimate data of primary experience, belonging to the order of knowledge, and ultimate elements of objects thought of as real in the fullest sense of the term, objects the nature and existence of which require inference, resting on data of primary experience, for their establishment. Now we have data of primary experience from which we derive our conception of force, and we have data of primary experience which, when that conception has been formed, we refer to force in material objects as their real condition, but we no more have an immediate experience of force as a primary datum of experience, than we have of solid material objects, called by me "remote" objects, such as fill the world of ordinary experience. Our knowledge of both alike rests on thought and inference drawn from data of primary experience. Consequently Mr. Spencer is deprived of his supposed known force, wherewith to contrast his supposed unknown

force, which we have already seen turns out to be a known one. Consequently also (and this is important with respect to his doctrine of force being as unlimited as time and space), since force can no longer rank among the elements or data of ultimate experience, there is no more reason for supposing it to be unlimited, in point either of duration or of spatial extension, than for supposing that the positively known or knowable material world, from which it is inseparable, and apart from which it cannot be positively conceived, is unlimited in those respects.

I am at one with Mr. Spencer in holding, that, beyond the material phenomena which are positively conceivable by man, there is some power or agency which is not positively conceivable by him. This we can only legitimately think of as power, agency, or even as real condition at all, when we at the same moment avow, that such terms are figurative, anthropomorphic, and inadmissible as speculative descriptions of its real nature. It is therefore a contradiction in terms to identify this power or agency, in point of its nature, with the physical force of which we have specific knowledge derived from experiences of touch and pressure, and the nature of which we for that reason can positively conceive. And it is consequently illegitimate to argue from such an identification, that the force which persists in the positively conceived physical processes of evolution and dissolution has the wholly unlimited nature of that Being, which we are compelled to think of as speculatively unknowable and unconditioned.

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The line between the speculatively knowable and the speculatively unknowable must be drawn, not where Mr. Spencer draws it, between force as known by intermittent experiences and force of which persistence must be predicated, but between the material world, or material part of the universe, in which force is positively known as an indispensable and persistent element, and those regions of the infinite and eternal universe which are not occupied by physical force and physical matter. These regions it is, of which we can only think, when we think or try to think of them speculatively, in figurative, anthropomorphic, and therefore wholly inadequate imagery. Mr. Spencer's view on the other hand, which identifies the really unknown and to us unknowable agencies of these Unseen regions with persistent physical force, unavoidably presents the Universe in its entirety as an abode in which physical forces reign supreme, to all those who (apparently unlike Mr. Spencer) attach a consistent meaning to the term *persistent force*, which he uses to describe it.

If, however, in consequence of the foregoing criticism of Mr. Spencer's theory of Evolution from a philosophical point of view, we understand it as restricted to the positively known or knowable material world, and applicable only within its limits, the theory affords an excellent and capital instance of what it is my main purpose at present to point out. I mean the fact, that every historical department of science, that is to say, the construction of the life-history of any concrete real existent, or class, or group of such existents, presupposes several analytical departments of science,

and the existence of general laws discovered therein, on the application of which that historical construction depends; although it is also true, and practically of great importance to note, that enquiries beginning in the historical department may equally well lead up to the discovery of general laws in the analytical department, as enquiries which begin in any department of analytical science. In fact it is events and sequences of events which are the πρότερον πρὸς ἡμᾶς, and normally act as the chief stimulus to curiosity.

I now, therefore, turn to that branch of biological science which has the history of life or living organisms as its object, that is, to Natural History in the accepted sense of the term. Some considerations brought forward in the preceding Section render it probable, that living matter has been produced or evolved, at some epoch in the past, by chemical in conjunction with physical processes, out of non-living matter, and possible that the same or a similar process may have been or may be again repeated by Nature. It is at least quite conceivable that it should be so. But when we turn to the history of life, so far as it is open to our actual observation, which is the case only on our own planet, we find it universally, or with very few exceptions, admitted by biologists that, in the present state of our knowledge, *omne vivum e vivo*, and even *omnis cellula e cellula*, are ultimate empirical facts. It seems that we must be content, for the present at any rate, to take some form or forms of living protoplasm as the *terminus a quo* of the history of living beings, and consequently to consider the relation between living protoplasm

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and non-living chemical structures as belonging to that branch of biology only which treats of the nature, and not the genesis, of life, that is to say, its analytical and fundamental branch; since we are unable to show any historical filiation of living from non-living matter, as an event or series of events in time. If such a filiation could be shown, it would bridge the cleft now existing, not only between chemistry and biology, but also between the two branches of biological science itself, by identifying the laws of the development of life, studied in Natural History, with those of its genesis or origin, which would then have been discovered in its analytical department.

In Natural History, then, the utmost that we can expect is, to be able to trace all the varieties of living organisms back to a certain small number of progenitors, or groups of progenitors, each group or kind representing, in conformity with the results of the analytical branch of biology, a particular variety of living protoplasm. To quote Darwin's words, towards the conclusion of his great work, the Origin of Species: "Therefore I cannot doubt that the theory of descent with modification embraces all the members of the same class. I believe that animals have descended from at most only four or five progenitors, and plants from an equal or less number.—Analogy would lead me one step farther, namely, that all animals and plants have descended from some one prototype. But analogy may be a deceitful guide. Nevertheless all living things have much in common,—in their chemical composition, their cellular structure,

their laws of growth, and their liability to injurious influences."[2]

What we should gain, then, supposing the filiation just spoken of to have been established, would be this, that we should then be able to affix a somewhat different and more definite meaning to the terms *first progenitor* and *prototype*. These words would then mean, not any individuals or types of animal or vegetable organisms indefinitely, but those varieties of living protoplasm, which could be shown to be ultimate by the analytic branch of biology. And Natural History would attain its goal the more completely, not according to its success in referring all the separate varieties of known organisms to the smallest possible number of original progenitors or prototypes in the distant past, but in referring them to those varieties of living protoplasm, whatever their number, which might be shown to arise or to have arisen, at any epoch, in consequence of purely chemical, or chemical and physical, processes. In short the true *terminus a quo* of the real evolution of life, which is the *terminus ad quem* of natural history, since history as a knowing is always retrospective, would, on the supposition in question, have been fixed by biology, which, as above said, is the fundamental and analytical branch of the science.

The doctrine *omne vivum e vivo* in natural history carries with it the supposition, that the first appearance of life on our planet took place at some undetermined epoch or epochs, and under peculiar conditions which have never again occurred, and which it is not attempted to describe, except in

[2] *On the Origin of Species*, Chap. XIV., p. 518, Third Edition, 1861.

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quite general terms. It carries with it this supposition because, as a doctrine of history, which assumes without attempting to account for the fact or the possibility of life, that is, for what would be commonly called its *creation*, or its nature and origination together, it as much excludes the generation of known living beings out of nothing, *e nihilo*, as it excludes their generation out of non-living matter. The purpose, then, of natural history is to trace back the generation of all known forms of life to the original organisms produced at those supposed epochs, in doing which the discovery of their relationships to one another is necessarily involved. It is here that the great conception of Darwin and Wallace, known as the law of natural selection in the struggle for existence, has proved of such extreme significance, by establishing, as for the first time it did, the reality of processes capable of connecting descendants belonging to wholly different species with a common progenitor or progenitors, by an unbroken series of changes, as minute as are to be met with in any province of Nature's operations. It may be noted, that Mr. Herbert Spencer's doctrine of the "instability of the homogeneous" supplies a theoretical foundation for the fact of incessant variability, which is the acknowledged pre-requisite for the law of natural selection.

The importance of this result for the whole system of human thought can hardly be exaggerated. Living beings, it is true, are but one class of real existents out of many, and the existing science of biology is not, like chemistry and the other physical sciences, a science possibly co-extensive with the

whole material world seen in one aspect, or in reference to one particular class of phenomena, but the science of one particular class of existents in all its aspects. Still it was just this particular province which presented the chief, if not the sole, remaining obstacle to unity in our conceptions of the Order of Nature. Now it was this obstacle which was surmounted for the first time by the establishment of the law of natural selection in the struggle for existence. The obstacle consisted, not in the real existence of natural species, but in the circumstance, that their existence appeared inexplicable save by the intervention of "final causes," or preconceived plans, as real determinants of the Course of Nature; that is to say, causes whose efficiency was wholly different in kind from that of material existents, and the mode of whose operation was not positively construable to thought Every natural species, in fact, seemed to owe its existence to an idea, or conceived type, existing as an idea or conception previously to the existence of the individuals of the species which realised it, and determining the individuals to be what they were, in order to realise it. Science was for ever relieved from this rivalry between the heterogeneous conceptions of final and efficient causation, or real conditioning, when once it was shown, that the natural species of living beings were explicable without the intervention of "final causes" or ideal types, and resulted as facts from the simply efficient operation of physical, chemical, and vital energies.

From this it by no means follows, that natural selection in the struggle for existence, founded on

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the occurrence and transmission of spontaneous variations, is the only line or mode of real conditioning which Nature takes in producing the divergence of relatively permanent species. The true connection of this line of determination with the nature and analysis of living protoplasm is a question which the discovery of the law of natural selection opened and prepared, but by no means answered. Darwin's own hypothesis of Pangenesis is a proof of this; and this hypothesis is but the first of a number of others which have since been proposed, with the view of placing the laws of descent and heredity on a sound analytical footing, by connecting them with the composition and structure of living matter as discovered, or to be discovered, by biological analysis, both in the vegetable and animal kingdoms.

But I am not proposing to enter here upon the consideration of any of these hypotheses. Important as they are, and of the deepest interest, they are questions for experts, and questions still *sub judice*. Nor would their settlement one way or the other, have any direct influence, so far as I can see, upon any of the philosophical problems which are the main subject of the present work, whether these belong to the theoretical and speculative, or to the practical and ethical, branch of philosophy. I therefore make my bow to them and pass on.

§ 6. Psychology.

§ 6. The next and last of the positive sciences, Psychology, is selective with regard to the objects of biology, just as we have seen that biology is selective with regard to the objects of chemistry. It selects as its object those living organisms which display, and so far as they display, consciousness in

the widest sense, I mean as including all kinds and degrees, from mere sentience upwards to the most complex manifestations of intelligence, emotion and, volition. The object-matter of psychology is thus double, comprising existents of two different kinds, living matter and consciousness, in conjunction. It is not a purely physical science, though dealing with material organisms. Neither is it a science of pure consciousness, though dealing with consciousness. It is consciousness in relation with the organisms which display it, or the display of consciousness by organisms, that is its object-matter. It thus closes the series of the great departments of positive science, by bringing us back to the study of consciousness, with the nature of which, or with which as a knowing in relation to what it knows, philosophy begins, by a special route, namely, by the enquiry into the Order of Existence, or the Order of Real Conditioning, in which consciousness now appears as what was called above, in Book I., a real existent, and one having its existence proximately conditioned on that of living matter.

My readers will have, perhaps, only too lively a sense of the dry analysis by which I endeavoured in that Book to establish the distinction between consciousness as a knowing and consciousness as an existent. It is not necessary to repeat it here. It is only in its existent character that Consciousness enters into the total object-matter of psychology. It is the psychologically subjective half of that object-matter. With the subjective aspect of consciousness taken by itself, that is, with consciousness objectified as a knowing

of various contents or objects, and taken in relation to them, which is its subjectivity in the philosophical sense of the term, and the objective aspect of which is not itself as an existent, but all things whatever, itself included, so far as they are known by it as a knowing,—with this philosophically subjective aspect of consciousness psychology has to do only so far as it is the immediate product or conditionate of neural activity, and also so far as (when self-objectified in reflective perception) it contains the evidence which enables the psychologist to designate and demarcate particular portions of it, take them as existents, and bring them into connection with particular neural actions or processes.

Every state or process-content of consciousness has the two aspects, subjective and objective, as they are distinguished in philosophy, inseparably united. And thus, when we say that consciousness as an existent is what belongs to psychology, it must be remembered that this is a very different thing from saying, that the objective aspect of consciousness is what belongs to it. The objective aspect of consciousness is one thing, the existent aspect of it is another, and is something included within and making a part of the objective aspect. With the objective aspect of consciousness in its whole range, that is, with what is known by consciousness as a knowing, and in that character or in that relation, it is philosophy not psychology that has to do. The existent aspect of consciousness is but one portion of this total field. Before anything can be thought of as an existent, the thought of it must have been objectified in consciousness, that

is, must have passed over, in reflective perception, from being part of consciousness as a knowing to being part of consciousness as a known. Now it is consciousness as a knowing, but as an existent knowing, objectified and thought of as such, and distinguished from itself and everything else in their character as known, or their philosophically objective aspect,—this it is with which psychology has to do; that is to say, with consciousness objectified as a knowing but in abstraction from what it knows, or as abstract awareness simply, and in the moment or series of moments of its genesis as an existent by the action of nerve-substance, which is its proximate real condition. In short, the existent character of consciousness, apart from the knowledge which it conveys or of which it consists, is the consciousness with which psychology deals, and which is one half, the psychologically subjective half, of its whole object-matter.

It may possibly here be objected, that consciousness has no necessary connection with matter, and consequently psychology no necessary connection with biology. And in support of this it may be maintained, that, where consciousness and matter are found together, matter is wholly subordinate, and performs a purely instrumental office; consciousness, or mind, the bearer of consciousness, having an independent existence, and making use of matter only as the means, or perhaps only as the occasion, of its own self-originated manifestation. But in order to render this reasoning legitimate it must first be shown, either (1) that consciousness *per se* has inherent agency, and is capable of acting as a real condition, which, I think, the analysis of

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consciousness given in Book I. goes very far towards disproving, or (2) that mind, or some other non-material bearer of consciousness, is a real and operative existent, which I think it will be difficult to show, seeing that no intelligible conception of a non-material and yet really operative existent has ever been framed, even by those most strongly convinced of its existence, namely, Aristotle and the Scholastics. The definitions given have either been chimerical, or else merely verbal or "that which" definitions, ascribing existence to the mind as *that which* produces the phenomena which it is desired to account for.

The question as to the nature of the agent or real being concerned in consciousness is one which psychology, as a positive science dealing with the order of real conditioning, that is, in this case, with real conditions of consciousness, or with consciousness itself as a real condition, must inevitably face. It cannot transfer its duties to philosophy, whether philosophy is conceived as metaphysic or as ontology. It may find indeed that its path coincides with that of metaphysic for a certain distance, that is to say, so far as simple analysis of consciousness is concerned. But, going only for this distance, in which the paths coincide, psychology would be merely descriptive and preliminary; not a positive science, endeavouring to trace the laws of the real actions upon which the described or analysed phenomena depend. And with the special task of metaphysic, the analysis of consciousness as a knowing, that is, in relation to objects generally, as that which is known by it, psychology has nothing whatever to do. If

psychology, therefore, is a positive science,—and it is either a positive science or nothing,—it cannot put off upon metaphysic its own special task of facing the question of the relation of consciousness to its real conditions, a question which arises only when the conception of real objects, real conditions, and an order of real conditioning, in some shape or other, has been framed by metaphysic either advanced or rudimentary, and in consequence of that conception having been framed.

Neither, on the other hand, can it put off the task upon ontology. Even supposing that ontology, which often popularly, but falsely, goes by the name of metaphysic, is a real pursuit, and establishes real conclusions, still psychology, in adopting these, must show that the agents and laws which they speak of are really operative in the phenomena of consciousness, which are its own field. But this is to face the question of real conditioning in consciousness. It must state definitely how it conceives the nature of the agent and agency involved in consciousness, whether it derives its conceptions from ontology or from biology. Unless the nature of the agent is made intelligible, it is impossible that the laws of its operations can be made so; for until they are definitely referred to the agent, it will not have been shown that they are laws of efficient operation at all, but they will be valid, if at all, merely as descriptions of the phenomena, not as laws of their real conditioning. Their connection with conditioning power will not have been made evident.

Now psychology takes rank among the positive sciences simply and solely by facing this question.

And it faces it by adopting a definite, intelligible, and verifiable hypothesis with regard to the real agent and agency concerned in consciousness, and to the laws, or general ways, in or under which that agency operates. Failing a metaphysical, and failing also an ontological hypothesis, such for instance as that of a special entity endowed with special capacities or faculties, to which special functions, such as sensibility, memory, imagination, understanding, reason, will, and so forth, correspond, biology supplies one which fulfils the required conditions. Nerve substance, a nervous system, and the energies which they display, in living organisms, are the hypotheton which psychology adopts from biology. It is quite conceivable that this hypothesis might be enlarged by including other tissues as well as nerve tissue, or other substances, such as the all-pervading ether, in the hypotheton. But nerve tissue is sufficient to establish the science on a real basis, and this at present seems to be the only tissue to which facts plainly and unequivocally warrant us in referring consciousness. In saying this, however, it must of course be understood, that nerve tissue and its operations are taken in conjunction with all the substances, forces, and energies, physical as well as chemical, with which they are inter-connected in living organisms; as, for instance, with the ether and its modes of action, which are supposed to penetrate all living as well as all non-living substances.

Construed in this liberal way, what the hypothesis maintains is, that we have no knowledge of the existence of any consciousness not conditioned

upon nerve tissue and nervous energy; and moreover, that for every mode of consciousness, and for every change in it, some modification or some change in nerve tissue or in its operations exists, and may conceivably be demonstrated to exist, as their real condition, whether antecedent or concomitant. It is evidently involved in this hypothesis, that nerve is always the real condition of consciousness, and consciousness always the conditionate, and never the real condition, of nerve or nerve-change. That is to say, there is real action and re-action between particles in nerve tissue, and between organs and parts of organs in a nervous system, as well as between nerve and other parts of the organism, and between nerve and external stimuli; but there is no real re-action of consciousness upon nerve, and no real action and re-action of states or processes of consciousness upon each other. Consciousness is a conditionate as well as a concomitant of the play of nerve energies, without re-acting upon them, and not possessing any energy of its own.—These views are entirely in harmony with the results reached in this and former Chapters, and with our provisional definition of Real Conditioning. Consciousness, though a real existent, is real as a conditionate only, not as a condition; or in other words, it is excluded from entering as a factor into the play of real conditions, and therefore from being subject, as such a factor, to the laws of the Conservation of Mass and the Conservation of Energy.

Thus, of the two heterogeneous parts of which the whole object of psychology consists, matter and consciousness, the latter is always conditioned on the former, and never *vice versa*. The conscious

being is double in this sense throughout his whole life, and in every state and process of it. What *he* is said to do, or feel, or think, is really done, felt, or thought, by his nerve organism. His nerve organism is the real agent or Subject. (I guard against a possible misconception of these statements in the following paragraph.) His consciousness is some mode of feeling or thought, or both combined, concomitant with, and conditioned upon, some physical nerve process, or some physical nerve action, to which latter alone his deed belongs. And the concomitant consciousness is often the only means we have of designating a nerve action or a nerve process. These for the most part are hidden from observation beneath the surface of the body. Nevertheless their real existence, and to some extent their nature, can be inferred from predictions when verified by observation and experiment, in just the same way that the ether vibrations are inferred in physics, or the atoms of elementary substances in chemistry. The conscious being, taken as single, and called *I*, or *He*, or the *Subject*, is, when taken as single, an object of the common-sense form of experience. Psychological analysis, resting on metaphysical, distinguishes this unit into its two inseparable parts, the real agent or real condition, which is the nervous system, and the concomitant consciousness conditioned upon it. Henceforward, then, I intend to designate this real agent alone as the *Subject.*

But now to guard against the misconception anticipated above. It seems absurd to say that a physical substance, such as nerve or brain, feels,

thinks, or consciously acts. But the apparent absurdity arises from our having to use forms of language which are based on common-sense ideas, and therefore imply indiscrimination between consciousness and its Subject, to describe the Subject alone, when, in scientific method, it is discriminated and taken in abstraction from its consciousness. That the concrete human being feels, thinks, and consciously acts, is true as well as familiar language. But then we have no other language wherewith to describe the Subject's conscious action, thought, and feeling, when we have separated it from them by analysis, and intend to speak of it as their real condition only. In no genuine analysis can the whole, which is analysed, be found again or repeated in any of the parts into which the analysis resolves it. Consequently, in saying that nerve and brain are the real agent or Subject, which feels, thinks, and acts, it is not intended to speak again from the common-sense or pre-analytic point of view, which clumps the Subject with its consciousness, or to imply that the agent, which is expressly said to be but the proximate real condition of consciousness, is, taken alone, the same thing as the concrete conscious being. The language which was used above, because no other is available, may only too easily be misconstrued, from want of attention to this simple consideration. What it is intended to convey is, that the whole agency in conscious action, feeling, and thought, lies solely in the nerve and brain of the concrete conscious being; or, in other words, that the whole conscious being's consciousness is as much theirs, when we consider

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it analytically, as it is his when we consider it pre-analytically. In short, we have, in the case of the conscious being, another and perhaps the most important instance of the fact, so often insisted upon in previous Chapters, that objects or phenomena as apprehended by common sense, are the *analysanda* and *explicanda* of philosophy and science.

It is precisely the heterogeneity of the two constituents of the conscious being, the object of psychology, which gives psychology its peculiar stamp and value. The fact that the two extremes of difference between real existents, matter and consciousness, can be brought together under a single conception, that of real conditioning, and studied together, as in actual experience they exist together, gives to the science which so studies them the position of a key science, locking together science and philosophy into one connected system, and unlocking or solving the problem of their relationship. Just as at one end of the series of sciences, the double character of matter, (1) as object thought of, and (2) as real condition, locked together, physical science and consciousness considered as a knowing or content of experience, so at the other end of the series, the conscious being, which is the object of psychology, locks together physical science and consciousness considered as a real existent. The heterogeneity is the greatest known to us, and yet it is made the object of a single science, in virtue of the conception of real conditioning, which, as we have seen, is the fundamental scientific conception.

For this conception is a very different thing from the old Scholastic conception of Cause. It is not pretended that nerve tissue, or any form of matter, produces consciousness out of its own fund, or in any way creates consciousness. Such a conception, wherever it occurs, is really no conception at all, being literally unthinkable. It is a notion drawn directly from the common-sense form of experience, and adopted wrongly, because without analysis, as a scientific or philosophical conception. When nerve is called the real condition of consciousness, what is meant is, that without it consciousness would not occur, but that with it, in certain states and processes, consciousness as a fact occurs, and occurs without the intervention of any positively knowable non-material agent. It was the extreme heterogeneity between consciousness and matter which, in former times, combining with the prevalent conception of Cause, seemed to compel a resort to the hypothesis, either of a special immaterial agent of consciousness, or of consciousness being endowed with agency of its own. But when once it is admitted, that the real *de facto* order of existence or real conditioning is the one great object of all science, and that laws, not causes, are the one thing which science purposes to discover concerning it; and when it is also perceived that to be a conditionate in that order does not necessarily involve re-acting on real conditions; and when, moreover, it is understood (a point which perhaps is the most important of all, in view of the old conception of Cause), that neither the nature of consciousness as awareness, nor the qualities of the ultimate modes of con-

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conception.

In taking consciousness, therefore, as an existent, and as such conditioned upon matter, and in saying that this conditioning relates only to the occurrence, order of occurrence, and degree of intensity, of states and processes of consciousness, we are making a restriction which is plainly necessitated by the fact, that the ultimate properties of states and processes of consciousness, including those properties which are the source of their quantity, namely, their time and space elements, as well as the specific qualities which they possess as feelings (properties which in Book I. were characterised as their *nature* or *whatness*), are ultimate data of knowledge, data concerning the real conditioning of which no question can possibly be put. For, try to put it, and you find you are assuming it again, both in putting the question, and in whatever answer you give. The ultimate properties of consciousness are, in other words, the *prius* of all knowledge and all questioning, which are modes of consciousness; just as matter including force is the *prius* of all positively knowable real conditioning. If science is knowledge, it must, therefore, in the last resort, rest upon the ultimate properties of consciousness, as its own ultimate and unquestionable data. That is, it cannot assume to account for their nature by referring it to dependence upon matter. Now it is just this impossible assumption which is made, whenever the Scholastic idea of Cause (instead of Real Conditioning) is applied to this case, and consciousness in its entirety, including its nature as well as its genesis, is said to be caused by, or to be the product of, matter and its physical

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energies, as if these were something self-existent and eternal.

It may be advisable to remark here, that the fact now noted of the ultimate, and inexplicable because unquestionable, character of the nature or whatness of states or process-contents of consciousness, as distinguished from the order of their production or occurrence, whether simultaneously or in succession, stands in no sort of conflict, but is entirely in harmony with the general fact or law established by Johannes Müller, known as that of the "specific energies of the senses," which is one of the great pillars of a thoroughly physiological psychology. That law imports, that each organ of external sense, the eye, the ear, and so on, responds by one specific kind of sensation only, notwithstanding the greatest variety in the kind of stimuli which are applied to it. Its neural constitution makes its activity the proximate real condition of a single class of sensations only. But although this law thus minutely differentiates the proximate real conditions under which we obtain sensations of different kinds, it still does not carry us beyond the domain of real conditioning; it brings us no nearer to answering the question, why or how it is that the sensations, which are thus determined to occur, should be of this or that specific quality or nature. The possibility of, or the reason for the sense-qualities of light, colour, heat, sound, touch, taste, smell, and for the nature of their formal co-elements, time-duration and spatial extension, as immediately experienced, being *what* they are when they are experienced, is not thereby discovered or assigned. All that is

accounted for is the fact that, given the possibility of these qualities and of their formal co-elements, they severally arise in us only under such and such specific conditions, that is, in case, but only in case, an appropriate organ of a specific constitution, is stimulated to activity. No *nexus* is shown between the quality and the organ or its activity, any more than between the quality and the stimulus acting on the organ. The only *nexus* shown is between the activity of the organ and the occurrence, not the quality, of the specific sensation. The quality *per se* escapes our questioning.—If it should be said, that at any rate a nexus is established between the formal co-elements of sensations and their real conditions, seeing that these co-elements, namely, time-duration and spatial extension, are common to consciousness and to matter which is its real condition, the answer is, that what these are in matter can be learnt only from what they are in consciousness, and therefore the fact that they occur in matter, and are constitutive of it, is no explanation of their nature being what it is, whenever they occur in consciousness. Again, therefore, the *nexus* in the real conditioning of consciousness is shown to be a *nexus* between occurrences only.

I return from these minutiæ to the primary difficulty which has always figured as the main objection to a physiological psychology, the difficulty of discovering a *nexus* between two such extreme opposites in point of kind as matter and consciousness, or in other words, of discovering the mode in which, the *modus operandi* whereby, the one becomes the real condition of the occurrence or

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coming into existence of the other. Now I do not profess that there is nothing here which we might conceivably know, but do not. What I maintain is, that what we do know is sufficient to constitute physiological psychology a positive science. We have the fact of a *nexus*, the fact of a *modus operandi*, demonstrated as an empirical law. The law of Gravitation itself, in dynamic, stands hitherto on precisely the same footing; it is an empirical law, the *modus operandi* which it implies being as yet undiscovered. Yet the law of Gravitation is the ultimate basis of the whole science of modern astronomy. The difficulty, therefore, of discovering the *modus operandi* in the real conditioning of consciousness cannot prevent physiological psychology taking its place among the positive sciences.

Moreover it must be observed, that in no positive and purely physical science is any law of real conditioning more than the discovery of the facts which are requisite and sufficient, whether as antecedent or co-existent, for the occurrence of certain other facts said to be conditioned by them. It is in this constant relationship, and in this alone, that what is called the *nexus* between condition and conditionate consists. The discovery of a real *nexus*, therefore, can never be anything more than the discovery, by analysing the process, of the minutest circumstances constitutive of such constant relationships, after sifting the facts, and clearing them of all irrelevant admixture. In the case of the real conditioning of consciousness, it would consist in showing, (1) what were the minutest changes in nerve substance, the arising and continuing of which, as a series of changes,

were always and alone accompanied by the arising and continuing of consciousness, or which made the nerve substance concerned pass from a state of unconscious to one of conscious activity, and (2) what were the minutest circumstances in the constitution of nerve substance, which enabled those minutest changes in it, when themselves set up by appropriate stimuli, always and alone to set up correspondingly minute states or processes of consciousness, which for that reason are said to be dependent on them.

But there is still more to be said. This difficulty of discovering the nature of the causal nexus, as it is called, in the present case, would be just as great on the assumption that consciousness was proximately conditioned on an immaterial substance or agent, whether it were called Soul or Mind. I mean, that this agent would equally with matter be heterogeneous to consciousness. The reason of this is evident. It is because the only idea we can form of an agent or a substance is derived from matter; and consequently the whole meaning which the term conveys is the idea of something material, only with the matter left out by a verbal fiction. The difficulty, therefore, of showing the *nexus* between such an agent and consciousness remains the same as before.

Suppose, however, we try the only other possible alternative, and assume that some form of consciousness is itself identical with agency, no agent other than consciousness being required or admitted. In this case two things are evident, first, that we are taking some psychological function or functions as our ultimate and self-existent cause of all

other psychological phenomena, and secondly, that any hypothesis of this kind must, in application, result in a theory, not of psychological phenomena, only, but of all phenomena whatever, that is to say, must issue in a psychological Ontology or Theory of the Universe. This is what we find has actually been the case. Four principal forms or functions of consciousness have been proposed (1) Self-consciousness, (2) Volition, (3) Perception in the largest sense, co-extensive with consciousness itself, and (4) Thought. I name them, not in historical order, but rather in that of their affinities to one another. All are nurslings of Kant's *Critic of Pure Reason*, all originate in the German Fatherland,—

Totaque Kantiacis Germania pinguis arenis,—

all have a strong family likeness.

Now the first of these forms or functions, that of self-consciousness, lands us again, and immediately, in the conception of an immaterial agent, only that it is now called, not Soul or Mind, but Self or Ego, that is, an agent the essential characteristic of which is to be self-conscious. Here the question is,—In which of the two, the agent or its essence, does the agency, or real conditioning power, lie? Is self-consciousness the real condition of the Ego, or the Ego the real condition of self-consciousness? In either case, what is the positive content of the Ego? The latter question is fatal to the hypothesis. The Ego as such, and apart from particular process - contents of consciousness, has no positive content at all. It is the inseparable feature of unity or continuity of time, involved as we have seen in all process-contents of reflective perception, and therefore belonging

also to that more complex form of reflective perception, in which a process-content of consciousness has several former process-contents of consciousness as its object-matter. It is a consciousness of other states of consciousness, as belonging to the same series with the present moment. That is to say, consciousness is the Self, which ought to be intended in the term *self-consciousness.* It is plainly a fallacy to take this feature of unity or continuity in time, which is inseparable from consciousness, separate it by abstraction, and hypostasise it either as an entity or an agency. Fichte, the eldest born of Kantianism, is the parent of this form of transcendental sophistry.

Or do we select Volition? Volition, as known experientially, requires the supposition, that different states of consciousness are already existing, before it can itself exist, since it is the act of choosing between such states. If, however, by volition is meant a pure and wholly abstract action, independent of any differences in consciousness, we are landed in the same form of the abstract entity fallacy which was noted above in the case of the Soul; we are making an entity out of an abstraction, which cannot, as an independent abstraction, be positively conceived. Volition, therefore, must be dismissed as a real condition of consciousness; and indeed Schopenhauer, its great prophet, did not profess to account for consciousness by it, without the aid of another co-equal partner, a form of consciousness which he named *Vorstellung.*

Vorstellung in the hands of Herbart, who is its particular apostle, has a range co-extensive with

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the whole of consciousness; it is the equivalent of what, in the present work, I call *Perception*. Here, then, we might seem at last to have reached some solid ground for a theory. But no. The solidity of the hypothesis is not commensurate with its range. The idea of substance is still requisite to enable us to conceive perceptions as agents. In Scholasticism the idea of substance was that of a single substance giving birth to, or being the bearer of, perceptions; in Herbart this substance is distributed among the perceptions themselves; each perception is a substance and acts as such, that is, acts in ways which can only be conceived by means of physical analogies. When perceptions cease to be perceptions, or in Herbart's imagery when they sink below the threshold of consciousness, so ceasing to be states of consciousness at all, they do not cease to act mechanically upon other states of unconscious consciousness which are, like them, "below the threshold." All, therefore, that Herbart's theory does is to load the already unthinkable idea of an immaterial substance with the self-contradictory conception of an unconscious consciousness, or of percepts unperceived at the time that they are percepts.

The fourth hypothesis remains, that of Thought, which has Hegel for its expositor. The theory founded on this hypothesis has secured to Germany, let us hope for ever, the undisputed primacy in philosophical extravagance. Hegel's theory is briefly this:—Thought is an energy actuating its own content, which is all consciousness, the laws by which it moves being the logical Principle of Identity and Contradiction, and the stages of its

movement being marked by Concepts, which are logical opposites or Contraries of one another. On this supposition, Hegel, starting from the most general concept, *Being*, constructs the whole universe of existence, whether positively known or in any way knowable, that is to say, Existence in its whole range of infinity and eternity. In other words, his theory is, that, Thought being the sole self-existent and productive agency, the laws of Thought are the only laws of Nature, and consequently Logic, as the theory of those laws, the sole Theory of the Universe.

The strength of this hypothesis lies in the profession which it makes, that the Thought intended by it is Thought as actually known in experience, not Thought as a transcendental abstraction. Consciousness itself, according to this theory, is agency; but it is only in one of its modes that it is so, namely, in Thought, and in Thought as we actually know and experience it. The Kantian embarrassment of a transcendent existence is thus apparently got rid of.

So much for its strength; now let us look at its weakness. Its weakness lies in the real incompatibility between thought as we positively know it by experience and the thought which the theory represents as the sole self-existent and productive agency in the Universe. Briefly stated, the incompatibility is this: thought as we know it by experience is a discerning and recording power, but, so far from producing the differences and similarities which it discerns and records, requires data to be supplied to it, upon which it may be exercised, and without which it would not itself

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come into existence; whereas thought as demanded by Hegel's theory (1) includes in itself all its content, (2) is a productive agency evolving that content, portion by portion, in accordance with logical laws alone. We have thus to choose between two opposite conceptions of the nature of Thought, that derived from positive experience and the Hegelian. If we take the Hegelian, our physical science is at once swallowed up in a Logic of the Universe, and our positive psychology in a psychology of the Divine Mind. The *Logic of the Universe* and the *Psychology of God* are then two names for one and the same thing.

This is a neat and at the same time a grandiose conception; but it is one which rests on arbitrary assumptions, and those assumptions inconsistent with what we know of thought by simple analysis of experience. In arriving at it, Hegel must, I think, have confused what I call consciousness or experience *per se*, that is, taken simply as process-content, which is the source of all our knowledge, with the Universe or Sum of Things, which is the object of a particular idea arising in consciousness or experience, and as such object (but only as such object) is necessarily thought of as including all real existence and all real agency or power. For in identifying thought with its content, and agency with thought, he leaves no place, or possibility of existing, for any object of thought which is not thinking but only object thought of, or for any agency other than that of thinking, though the existence of such agency, and of such objects thought of, is plainly to be inferred from positive experience.

In support of these contentions I rely on the analyses already given or remaining to be given in the present work. For Thought, as we actually know and experience it, is analysable, and when analysed is found to have other modes of consciousness, namely, perceived feelings or percepts, of various kinds, as its pre-suppositions, which furnish it with a content, and without which it would not itself exist. The most general concept, *Being*, with which Hegel's world-construction begins, is analysable into elements, some of which are percepts antecedent to the concept itself, and to the conceiving process. There is, therefore, some agency which brings percepts into existence, other than the agency of Thought; and in saying *percepts* we virtually say the whole content of consciousness other than the logical form called the Principle of Identity and Contradiction, and the logical forms which are its derivatives. Consequently, on the supposition that Thought as we know it is the only agent or agency, its whole agency must lie in the Principle of Identity and Contradiction, abstracted from the concepts from and to which it moves. But this is the same thing as saying, that the Thought which is agency has no positive content at all, and is not positively conceivable except as a purely formal element involved in consciousness, the really operative agency in which must be looked for elsewhere. To assume that this abstract element in consciousness is an agency, which can first produce and then mould the remainder into a systematic experience, is to make an entity of an abstraction,—the same form of fallacy which we have already met with in the Scholastic theory of vitality.

I conclude, then, that it is impossible to raise Thought, as we actually know it in experience, into a real and independent agency, because in so raising it we have to take it as an abstraction hypostasised, which is not only never the way in which it occurs in actual experience, but the possibility of which, on the contrary, is a many times exploded fallacy. The skill with which Hegel recommends this well-worn fallacy to his own acceptance, as well as to that of others, entitles him to rank as the last and perhaps the greatest of the Scholastics. His admirers, I suppose, would unhesitatingly maintain, that he has quite eclipsed Duns Scotus.

It is necessary in the next place to advert to the properties and functions of that physical nerve substance, and also to those of that neuro-cerebral system, which all scientific psychologists admit to be *sine qua non* conditions of the phenomena of consciousness as we know them, and which I hold to be their sufficient conditions also, in the sense above assigned, in their case, to the conditioning process. Of course, I do not exclude the idea, that further knowledge may render the fact of this sufficiency more evident, by the discovery of more and more minute correspondences between the condition and the conditionate. I confine myself also to the human Subject, as being the field which has hitherto been more especially examined, as well as offering, on the psychologically subjective side, the greatest facilities for examination. And here again, as in other cases, I must have recourse to

authority. Moreover, it must be understood, that I quote only the indispensable minimum for my present purpose. First, then, as to the properties and functions of nerve substance, before going on to consider those of the neuro-cerebral system.

"It is obvious," says Professor Schäfer, "that the nerve cell must always form the basis of the science of Neurology in all its branches."[1]

After remarking that we are only now beginning to arrive at a definite understanding with regard to it, Professor Schäfer thus proceeds:

"We may most naturally begin with the *structure* of the nerve cell. I do not know why we should restrict the term "nerve-cell" to the body of the cell, and thus exclude from that term the cell-processes. This is not done for any other kind of cell."[2]

He begins. however, very properly, by speaking first of the cell-body, with its nucleus and nucleolus. Of the cell body he says, later on, that its "first and most prominent function is unquestionably that of nutrition; and this function is, in all probability, dependent upon the presence of the nucleus."[3] I pass over, as not immediately bearing on my present purpose, what is said of its size, and that of the nucleus and nucleolus, both absolutely and relatively to the processes; the reticulate structure; the pigmentary matter, and so on; and pass at once to what is said of the processes. Of these processes

[1] *The Nerve-cell considered as the Basis of Neurology*, being the Presidential Address delivered at the Annual Meeting of the Neurological Society, Jan., 1893. By Professor E. A. Schäfer, F.R.S. Published in Brain, Double Number, Parts LXI., LXII., 1893. Page 134.

[2] *Ibidem.*

[3] *Ibidem*, p. 150.

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"Every nerve-cell has one or more; it is an absolute characteristic of nerve-cells to possess processes. The processes are of two kinds. The first and only essential kind is that which has long been known as the axis-cylinder or nerve-fibre process (Deiters). It is also the first kind to show itself in the course of development of the nerve-cell." [Reference is here made to W. His, *Die Neuroblasten und deren Entstehung im embryonalen Mark*, in the *Archiv für Anatomie*, 1889.] "The other kind is that which was distinguished by Deiters as the protoplasmic process. This is not so essential, for we find many nerve-cells entirely destitute of it."[4]

The axis-cylinder or nerve-fibre processes he proposes to call *neurons*, and the protoplasmic processes *dendrons*. (*Ibid.*) It is the former by which the reception of sense impressions from without, and the transmission of impulses or impressions from cell to cell are principally, if not solely effected. Not, however, that this involves strict continuity of substance. "All processes of nerve-cells are ultimately *dendritic*. Almost without exception the neuron or nerve-fibre process, although it may have a course of several feet without giving off a branch, finally ends in a terminal arborisation," that is, in a number of minute twigs, pictured in a figure accompanying the text, which envelop without actually touching the nerve-cell or other structure to which they go.[5]

Both neurons and dendrons have an apparently fibrillar structure; but several competent observers

[4] *Ibidem*, p. 136.

[5] *Ibidem*, pp. 138, 152, 157, 159—164.

have maintained (F. Nansen's work, *The Structure and Combination of the Histological Elements of the Central Nervous System*, Bergen, 1887, being referred to), that "the apparent fibrils are really the optical longitudinal sections of sheaths or septa of spongioplasm, which subdivide the fibre into tubes filled with hyaloplasm, which forms the true conducting material of the nerve-fibre."[6] However, it would seem that these observations still require harmonising with those of Max Schultze, according to which there is always a discontinuity of the individual fibres.[7]

As regards the relation which nerve-cells bear to one another, our recently acquired knowledge is recorded as follows:

"We can now state by virtue of observations which have accumulated since the employment of Golgi's method of staining, that, firstly, there is never a direct union of nerve-cells by comparatively coarse fibres; secondly, there is not even a union of nerve-cells by means of a network of fine fibrils; and thirdly, that every nerve-cell with all its processes is a distinct and isolated anatomical unit. We can further state with great probability that the only connection of one nerve-cell with another is a physiological one, and that it takes place by the adjunction of the arborised process or processes of one nerve-cell, either with the cell-body of another cell, as in the cerebellar cortex (Figures given) and in various other parts, or by the adjunction and interlacement of the arborised processes of one nerve-cell with similar arborised processes of other cells, as in the olfactory glomeruli

[6] *Ibidem*, p. 144. [7] *Ibidem*, pp. 142—145.

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(Figure given). In fact we may regard the basis of the grey matter of the nervous system—the granular-looking substance in which the nerve-cells are embedded—as an extremely fine interlacement of ramified processes, not only of the nerve-cells which actually lie in that particular grey matter, but also of nerve-cells which lie in other parts of the nerve-centres or even in the peripheral parts of the nervous system, and which on arriving at the grey matter similarly break up into a fine arborescence of nerve-fibrils." [8]

The combination of the two facts of anatomical isolation and physiological continuity between nerve-cells, including their processes, entirely harmonises with the circumstance of that loss of time which is known to be specially due to the passage of a nerve-impulse from one cell to another, as for instance in the stimulation of a motor cell in the spinal cord by excitation of fibres in the pyramidal tract. The whole phenomenon seems thus to be one of stimulation, not of transmission merely; that is, an impulse is transmitted from one cell, and another new impulse is aroused in the cell to which it goes, and which is said to be stimulated by the former impulse. The question then arises, In what way the process of stimulation is to be conceived, both in the case of influences coming from the environment, and of influences set up in nerve-cells, and imparted by nerve-cells to one another.[9]

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[8] *Ibidem*, pp. 147—148.

[9] *Ibidem*, pp. 163-166. See also Dr. A. D. Waller's *Introduction to Human Physiology*, 2nd Edit., 1893, p. 480, where we read as follows: "It is most natural from a physiological standpoint to speak of nerve-cells as being in protoplasmic *continuity* with nerve-fibres; but according to modern histologists (Golgi, Ramon y Cajal, Retzius), such continuity is in many instances absent, the relation (which applies to peripheral as well as central cells) being one of

It must, however, be noted, that, though it is well for psychologists to treat the anatomical isolation and discontinuity between nerve-cells as established facts, inasmuch as they are, at first sight, less favourable to their doctrine of the dependence of consciousness on nerve-action, than the older hypothesis of continuity, yet that they are established facts, is at present by no means universally admitted. A masterly study of Professor Golgi's "chrome-silver method," and a criticism of its results, are contained in Dr. Alex. Hill's Presidential Address to the Neurological Society for 1896,[10] in which he refers to that Address of his predecessor in the Chair, Professor Schäfer, upon which I have been so largely drawing.

The so-called automatic action of nerve-cells remains to be spoken of. I return to Professor Schäfer's Address, but I take what he says on this point somewhat out of the order in which it there appears. "It is," he says, "almost universally held that nerve-cells may act as generators of nerve-impulses; that in fact they may function as independent nerve-centres. But it is by no means easy to bring forward direct proof of this action."[11] Clearly we must distinguish between nerve-cells and nerve-centres; the latter may include a considerable number of the former. In fact a nerve-centre is a physiological unit, a nerve-

contiguity between nerve-cell and a surrounding network of fine fibrils. * * * But this anatomical discontinuity does not involve functional discontinuity: a nerve-impulse along a pyramidal fibre can *influence* a motor cell, and physiologically we may picture the process as taking place along a continuous strand of excitable protoplasm."——Professor Ramon y Cajal's researches also are now readily accessible, in *Les Nouvelles Idées sur la structure du Système Nerveux chez l'Homme et chez les Vertébrés*, par Le Dr. S—R. Cajal, Professeur d'Histologie à la Faculté de la Médecine de Madrid. Traduite de l'Espagnol par le Dr. L. Azoulay. 2me tirage. Reinwald, Paris, 1895.

10 Published in Brain, Part LXXIII, Spring Number, 1896.

11 *The Nerve-cell considered, &c.* In Brain, Parts LXI.—LXII., 1893, p. 153.

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cell an anatomical one. No one, I imagine, would think it possible or desirable to prove, that a nerve-cell, or whatever element was taken as an ultimate element, either in anatomy or in physiology, could strictly speaking initiate action without stimulus or environment of any kind. In all physical and therefore in all physiological matter, we know of no concrete action that is not inter-action. But this also involves the idea, that there is no portion of matter in which action does not originate, or rather in which it is not always originating. This is the conception which Newton expressed by attributing *vis insita* to every part and particle of matter.

Professor Schäfer admits all that any psychologist would demand, in the passage with which he concludes this part of his subject: "The action of the nerve-cells cannot therefore be said to be truly automatic: in other words, the nervous impulses do not arise *de novo* without any obvious external cause by the action of the cell-substance. And I think that it would be difficult to instance any "automatic" action which might not also be referred either to a chemical stimulus due to variations in the blood or to stimuli reaching the centres from the periphery, or from some other parts of the nerve-centres."[12] The last eight words contain all that is necessary for psychological automatism. I say all that is necessary, because these words plainly leave room for the fact of self-determination, that is to say, for the action of a system of nerve-centres as a whole, being the

[12] *Ibidem*, p. 155.

resultant of inter-actions between its parts, which is the physiological basis of volition, or the conscious self-determination of choice between alternatives, which is also known as Free-will.

I turn now to the second part of the task proposed above, namely, to consider briefly the nervous system and its functions as a whole. Here I gladly again avail myself of Professor M. Foster's valuable *Text Book of Physiology*, on which I have already drawn so largely, citing in the present case from the third Chapter of Book I., *On the more General Features of Nervous Tissues.*

"The Nervous System," writes Professor Foster, "consists (1) of the *Brain and Spinal Cord* forming together the *cerebrospinal axis* or *central nervous system*, (2) of the *nerves* passing from that axis to nearly all parts of the body, those which are connected with the spinal cord being called *spinal* and those which are connected with the brain, within the cranium, being called *cranial*, and (3) of ganglia distributed along the nerves in various parts of the body." [13]

This account includes what is called the sympathetic system, as well as the cerebro-spinal. "We may say at once, without entering into details, that the whole of the sympathetic system with its ganglia, plexuses and nerves is to be regarded as a development or expansion of the visceral or splanchnic divisions of certain spinal nerves." [14]

The spinal cord is a centre uniting afferent and efferent fibres, by means of the grey matter which it contains; the chief function performed by the

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[13] Work cited, Part I., § 96, p. 169.
[14] *Ibidem*, p. 171.

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afferent fibres being sensor, inasmuch as they are distributed to sense-organs at the periphery and elsewhere; and the chief function of the efferent fibres being motor, inasmuch as they are distributed to muscles and other contractile tissues.[15] This description, which I gather from what is said by Professor Foster in the passages quoted and elsewhere, may be applied *mutatis mutandis* to the brain, which he takes the spinal cord as in some measure representing. The principal change would I imagine consist in this (though here I am giving my own interpretation only), that intra-cranial nerve centres are related to one another by fibres performing functions analogous to those called afferent and efferent in the case of the spinal cord; that is to say, they both transmit and receive stimuli to and from one another, which are functions enabling them collectively to act as the organ or organs of representation, emotion, intelligence, and volition.

Now there are two great functions belonging to nerve centres, which are peculiar to the cerebro-spinal system. What these are will be seen from the following passage.

"It is only in some few instances that we have any indications, and those of a very doubtful character, that the ganglia of the splanchnic system can carry out either of the two great functions belonging to what is physiologically called a *nerve centre*, namely the function of starting nervous impulses anew from within itself, the function of an *automatic centre* so-called, and the function of being so affected by the advent of afferent impulses

[15] *Ibidem*, § 100, p. 178. Compare also § 68, p. 118, and § 96, p. 171.

as to send forth in response efferent impulses, of converting as it were afferent into efferent impulses, the function of a *reflex centre* so-called.

"It is the central nervous system, the brain with the spinal cord, which supplies the nervous centres for automatic actions and for reflex actions; indeed all the processes taking place in the central nervous system (at least all such as come within the province of physiology) fall into or may be considered as forming part of one or the other of these two categories." [16]

Reflex actions are the first treated of. In regard to these we read: "In a reflex action afferent impulses reaching the nervous centre give rise to the discharge of efferent impulses, the discharge following so rapidly and in such a way as to leave no doubt that it is caused by the advent at the centre of the afferent impulses." [17]

"Reflex actions can be carried out by means of the brain, as we shall see while studying that organ in detail, but the best and clearest examples of reflex action are manifested by the spinal cord; in fact reflex action is one of the most important functions of the spinal cord." [18]

A somewhat detailed description of reflex actions is then given, concluding with the following passage:

"In other words, a centre concerned in a reflex action is to be regarded as constituting a sort of molecular machinery, the character of the resulting movements being determined by the nature of the

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[16] *Ibidem*, § 100, p. 179.
[17] *Ibidem*, § 101, p. 179.
[18] *Ibidem*, pp. 179—180.

machinery set going and its condition at the time being, the character and amount of the afferent impulses determining exactly what parts of and how far the central machinery is thrown into action."[19]

As regards the other great category, that of automatic actions, we find them thus spoken of:

"Efferent impulses frequently issue from the brain and spinal cord, and so give rise to movements without being obviously preceded by any stimulation. Such movements are spoken of as automatic or spontaneous. The efferent impulses in such cases are started by changes in the nerve centre which are not the immediate result of the arrival at the nerve centre of afferent impulses from without, but which appear to arise in the nerve centre itself."[20]

Such, for instance, are probably the impulses, arising in a certain part of the medulla oblongata, from changes rhythmically recurring in its nervous material, whereby the action of rhythmically repeated breathing is brought about.[21]

"From the brain itself a much more varied and apparently irregular discharge of efferent impulses, not the obvious result of any foregoing afferent impulses, and therefore not forming part of reflex actions, is very common, constituting what we speak of as volition, efferent impulses thus arising being called volitional or voluntary impulses. The spinal cord apart from the brain does not appear capable of executing these voluntary movements;

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[19] *Ibidem*, p. 182.
[20] *Ibidem*, § 102, p. 183.
[21] *Ibidem*.

but to this subject we shall return when we come to speak of the central nervous system in detail." [22]

But in addition to these two great categories, or, at any rate, as a special class of actions to be subsumed under them, the inhibitory actions of certain nerve fibres are to be mentioned. The impulses transmitted by these nerves, so far from stimulating, have the effect of hindering, weakening, or altogether stopping the activity of the organs to which they are distributed; muscles, secreting glands, and nervous centres, being adduced as instances. "Such an effect is called an *inhibition*, and the fibres stimulation of which produces the effect are called 'inhibitory' fibres." [23]

"It is probable, though not actually proved in every case, that wherever in any tissue energy is being set free, nervous impulses brought to bear on the tissue may affect the rate or amount of the energy set free in two different ways; on the one hand, they may increase or quicken the setting free of energy, and on the other hand they may slacken, hinder, or inhibit the setting free of energy. And in at all events a large number of cases it is possible to produce the one effect by means of one set of nerve fibres, and the other effect by another set of nerve fibres." [24]

Of all the forms of consciousness from the lowest sensation to the highest emotion, from simplest perception to the most complex representation, from the most effortless association to the highest effort of imagination, thought, or volition, I do not think there is one which

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[22] *Ibidem.*
[23] *Ibidem*, § 103, p. 184.
[24] *Ibidem*, p. 185.

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may not readily be conceived as dependent for its appearance in the conscious field upon one or more of the three modes of neural activity thus briefly depicted, reflex, automatic, and inhibitory. And the whole mechanism rests, as the passage last quoted clearly indicates, upon the phenomenon of the storing and setting free of energy, a phenomenon common to the whole physical and physiological world.

We can now see in some measure how it is, that the physiology of the nervous system supplies us with a real condition of consciousness, unimpeachable as an hypothesis, which cannot in my opinion be either replaced or supplemented by a better, human sensitivities, and human modes of thought founded on them, being what they are.

In my opinion, the property of nerve tissue, which more than any other enables it to serve as an adequate hypothesis accounting for the occurrence of all forms of consciousness, and especially of the highest intelligence, volition, and emotion, is its property of automatism or spontaneity. In the lowest forms of consciousness, I cannot, for my own part, understand irritability, that is, the capacity of responding to stimulus, without conceiving it displayed by automatically acting substance, that is, substance between whose internal parts changes, not externally initiated, are constantly going on. Automatism seems to me the condition of irritability, somewhat in the same way as *vis insita* is the condition of response to *vis impressa*, only in more complex matter. The lowest living organism, the simplest cell of protoplasmic matter, is a certain comparatively stable compound of chemical ele-

ments,—as shown in §§ 4 and 5;—and the action of such a comparatively stable compound must of necessity be automatic. The lowest forms of consciousness are those which depend upon a response of the organism to stimulus, in which response automatic action is necessarily involved.

As to the higher forms of consciousness, it is plain that action apparently self-initiated, I mean such action as we express by the phrases *I will, I won't, I think, I see, I do*, and so on, is the common-sense phenomenon, for which we have to find a real condition; and then, considered as such a real condition, the automatism of nerve tissue has at any rate one advantage over the automatism of immaterial substance, namely, that of being distinctly construable to thought. If we had a positive intuition or perception of our immaterial Self or Ego acting, the question of the real conditioning of such actions as those just mentioned would be answered as soon as asked. In reality, the immaterial agent is a fictitious addition to our consciousness of re-actions, the real agency in which, whatever it really consists in, being wholly intracerebral, is unperceived at the time of re-acting, and therefore cannot be immediately perceived, but only inferred, to be connected with those phenomena of feeling, sense of effort and the like, which are the characteristics of those process-contents of consciousness which we designate as cases of conscious activity. Those higher forms of consciousness, therefore, which we class as conscious activities, must be conceived as cases in which the immediate action is exclusively automatic, since in them the stimulus is received, not from

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beyond the nerve organism, but from some other part or parts of the same intra-cerebral mechanism. And their characteristics in consciousness, such as sense of effort, sense of difficulty, sense of comparison, sense of deliberation, and sense of choice or actual decision, can only be rendered intelligible by conceiving them as dependent concomitants of such intra-cerebral inter-actions.

I cannot but believe that a great part of the reluctance to accept nerve tissue as the only proximate real condition of consciousness arises from a purely childish mistake as to the meaning of *automatism.* Figures of wood, wax, &c., set in motion mechanically, are popularly called *automatons,* because, though worked by agency not forming a necessary part of their own substance, they simulate automatic action. Hence in popular language an automaton has come to mean something worked by alien forces, that is, something the precise opposite of what it is in its true meaning. And thus many worthy people object to man's being called a *conscious automaton* for the very reason which shows that he is one, namely, that he initiates actions from within. The words *within* and *without,* used in reference to the origination of real action, imply a material structure, when they are strictly and not metaphorically taken. Metaphorically taken they only mean, or rather aim at meaning, something which is not matter; and supposing this something to be an immaterial substance, the objectors would present us with the very thing they object to, namely, the false kind of automatism; for the organism would then be mechanically worked by an agent inhabiting it, but foreign to itself.

It may, however, be questioned whether this branch of the alternative is often, or ever, distinctly embraced by those who object to what they call automatism. More frequently what is meant by the something which is not matter is consciousness itself, the objection being drawn directly from the common-sense view of things. We are supposed to act, either because we have a feeling, or because we have a thought, prompting or deciding on a particular bodily action. The feeling or the thought, in either case a state of consciousness, is then supposed to be a really operative link in the chain of events, to be that link, in fact, upon which our bodily action is immediately conditioned. As, for instance, in walking along a road, if I see a wheelbarrow standing in my path, I avoid it; if I do not see it, I stumble over it. The *seeing* or *not-seeing*, characterising my state of consciousness, is then held to be the circumstance which determines the action on my part, determines whether I shall stumble over the wheelbarrow or not.

This is excellent as common sense. But it will not bear erecting into a psychological theory, because the seeing or the not-seeing spoken of is taken unanalysed, without adverting to the possibility that it may consist of heterogeneous parts, that is to say, of nerve processes and concomitant states and processes of consciousness, the latter characterised either by the presence or by the absence of the perception of the wheelbarrow. Until this distinction has been expressly drawn by analysis, the seeing or the not-seeing, as a state of consciousness distinct from the concomitant nerve process, cannot be taken as a real link contributing

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to determine a chain of events; and consequently the statement, that, seeing or not-seeing the wheelbarrow is such a link, has no psychological value.

Still it may perhaps be said, that this criticism is purely negative, and leaves the rational or purposive character of the connection between the special nerve action, subserving perception of the wheelbarrow, and the special nerve action employed in avoiding it, wholly unaccounted for. Only a final cause, it may be contended, such as the idea or purpose of escaping a fall, or at any rate a state of consciousness of some sort or other, is adequate to explain how it is, that the highly special action of avoiding the wheelbarrow, and no other, follows upon the other highly special action involved in seeing it. The answer to this contention, the positive explanation demanded by it, is, that the man who avoids the wheelbarrow on seeing it is one of those agents, in whom nerve actions, more or less precise, necessary to avoid obstacles, are already so associated with nerve actions more or less precisely subserving perception of obstacles, as to be stimulated and set in operation by them; since only those agents survive, or continue long in safety from fatal accidents, in whom such associations are formed. Even if the idea or purpose of escaping a fall is present in the action, it is probably only as a concomitant depending upon some part of the process associating the two special nerve actions in question, and not as a real link in the real conditioning of one by the other. A minute association of neural processes *inter se* is the real, and the only positively

conceivable, explanation of the phenomenon we are considering.

The main source of our thus mistaking a common-sense statement for a scientific one consists in the facts noticed above, first, that we are not immediately aware of nerve process as such, and then that, when we have become aware that it always exists in cases of consciousness, we still have no other means of apprehending it but the states of consciousness concomitant with it. The concomitant consciousness, therefore, readily comes to stand, in our imagination, as if it were the essential part of the whole phenomenon, and not a concomitant without influence on the action. Thus in the case of seeing or not-seeing the wheelbarrow in the path, what we are alone entitled to say is this: I avoid the wheelbarrow, if a nerve process takes place in me, such as is normally accompanied by a perception of a wheelbarrow; and unless that nerve process takes place I do not avoid it.

The parts of the nerve mechanism which subserve visual perception and muscular movement are in continuous physiological or functional connection, and this implies that the nerve action, which stimulates the limbs to act so as to avoid the wheelbarrow, can be set up by actions in a central organ or group of organs, which are themselves set up in those organs by that action of ether vibrations on the retina, which subserves the visual perception of the wheelbarrow. The nerve mechanism receives, transmits, and sets up physical energies, and subserves consciousness (at least for one part of the whole process) at one and the same time.

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I say for one part of the whole process, because the whole process begins with the setting up of motions in the nerve mechanism by the physical action of the ether vibrations, and we must suppose that some period, often so short as to be inappreciable, elapses before these motions attain that intensity which is attended with consciousness, the moment of their attaining which is what is known as the threshold of consciousness. Similarly at the end of the process, the nerve motions may be supposed to continue for a period, more or less brief, after the ceasing of the consciousness which accompanies them, which, to continue the metaphor, would be the moment of recrossing the threshold. And the same suppositions may very well be made concerning each change in consciousness, intermediate between the beginning and end of the two-fold process.

But throughout the whole of this process, consciousness is initiated by, and depends on, nerve motion, and not *vice versa;* for there is no step or stage in the process at which we can conceive the relation between neural process as condition and consciousness as conditionate to be inverted. To do so would involve the assumption, that, at some point or other of the process, either consciousness began to act as a real condition (having previously been a conditionate only), or an immaterial agent, which had previously been dormant, was roused into activity. But neither alternative is positively conceivable ; neither of them has any observed facts in its favour. On the other hand we can render all the phenomena positively intelligible, on the hypothesis of neural action as

above set forth. Whenever we can observe the origination of consciousness, as in sense-presentations, we find it depending upon neural action, as well as concomitant with it. And the whole nerve organism is a systematic and physiologically continuous structure. The only conclusion, therefore, which experience warrants is, that consciousness in all its forms, and whenever it occurs, is not only the concomitant but also the dependent concomitant, or conditionate, of neural process, and that this order of dependence is never inverted.

This view of the matter gives the true sense in which we must understand the dictum, *nihil in intellectu quod non prius in sensu*, together with its equally legitimate restriction, *nisi ipse intellectus*, as applied to our knowledge both of an external world, and of our internal feelings and ideas. All the material of knowledge comes to us by nerve processes which subserve perception, whether internally or externally initiated ; and all our ideas concerning it, that is, all the relations perceived or imagined between its parts (when not included in the original perceptions), and all the emotional feelings accompanying those ideas, are subserved by nerve processes which are in continuous physiological connection with the former. The original, or as they may be called, the *presentative* processes of perception, initiated as well from within as from without the nerve mechanism, are taken up and carried forward by *representative* processes, that is to say, by redintegration, either spontaneous or volitional. Everywhere and always the processes are the same in this respect, that they are double processes, consisting of two concomitant parts,

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nerve motion and consciousness, the latter of which is dependent upon, or conditioned by, the former, and never *vice versa.* Instead of reading *intellectus,* in the dictum just quoted, which is an abstract function hypostasised as an agent, we must read *those cerebral processes which subserve redintegration;* just as instead of *sensus,* as an hypostasised function, we have already become accustomed to read—*those neuro-cerebral processes which subserve sense-presentation.* In an organised being like man, processes of the former kind are inevitably set up by processes of the latter kind, and the consciousness which is conditioned on the former is consequently a continuation, with modifications, of the consciousness which is conditioned on the latter. The conception of an immaterial agent endowed with two modes of functioning, sense and intellect, even supposing it thinkable, would here be superfluous.

Nor is the case altered, so far as this fundamental relation between nerve and consciousness is concerned, when we come to the highest and most complex forms of consciousness, volition, reasoning, emotion, or the intimate self-communings of the heart. Terms like the heart, the will, the reason, the intellect, the mind, the soul, the spirit, are either (like the terms *I*, *Ego*, and *Self*) unanalysed terms of common sense, not of psychology, or they are compendious modes of characterising certain classes of phenomena without adverting to their analysis. The broad fact remains the same, that the real agent and the real agency concerned in them are the brain and brain processes, upon which the states and processes of consciousness, as im-

mediately known to us, are conditioned. This fact is hidden from us, as before, by the facts (1) that the common-sense experience is undeniably true as fact simply, and (2) that the particular organs and processes in the brain, upon which the experience depends, are more difficult of access, and consequently involved in deeper obscurity, than those of almost any other part of the nervous system.

Thus, for instance, when a wholly new idea, or sudden thought, flashes into consciousness, unconnected with whatever we may be engaged upon at the moment, and becomes the origin of a new train of ideas, its occurrence is due, not to any unaccountable inspiration of the Soul or Self, but to the inter-action of some parts of the redintegrative mechanism, which till then had been working with an energy below the degree at which the threshold of consciousness is passed. There are also cases of more frequent occurrence, where a new thought or idea, apparently unconnected with what we are engaged upon, flashes into consciousness, the reason of which may be traced, on reflection, to an association between some comparatively unnoticed part or feature in what we are engaged upon and the newly occurring thought or idea, which latter we then recognise as a reminiscence of some forgotten experience. Of such traceable associations the permanent nerve mechanism supplies the only explanation which is scientifically admissible.

Again, when a sudden decision is taken, or there is any decisive adoption of one out of several alternatives, whether these are clearly or dimly present in consciousness, the act of choice is due, not to the superior attractiveness or pleasurableness of the

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alternative chosen, which are feelings or perceptions, but either to an increase of energy in the neural process which subserves it; or to the energy of some connected neural process being directed exclusively upon the one subserving it, so retaining it in consciousness; or thirdly to energy, derived from another similarly connected neural process, inhibiting those which subserve the rejected alternatives.

Both the spontaneous occurrence of the sudden idea, and the volitional act of choice between alternatives, arise directly from operations of the neural mechanism, notwithstanding that both are necessarily described in terms of consciousness, and that both are referred in common-sense thought to the concrete conscious being, as their Subject in the one case, their Agent in the other. It is in this common-sense way of thinking of volitional acts, that the conception of purpose, design, or final cause, has its origin.

The essential difference between biological or physiological psychology and its rivals, I mean theories based on the hypothesis, either of an immaterial substance, or of energy in consciousness itself, consists in the materiality of the agent which it assumes to build on. It does not consist in the special selection of nerve tissue. It is with nerve tissue that it makes a beginning, but the importance of the step which it thus takes lies in the fact, that nerve tissue is a form of Matter. And it must be remembered, that biological or physiological psychology is a science still in its infancy. The study of nerve tissue as pervaded by some, and cooperating with all, the physical forces and physical

substances of Nature, and perhaps more especially with that etherial substance, the vibrations of which are the vehicle of light, heat, electricity, and magnetism, has presumably a vast field of discovery before it. We can even imagine the possibility of the ether itself becoming vitalised, and acquiring organic structure, from the tissues of the living organisms which it pervades. But apart from any suggestion of this sort, we may well conceive, that special sensibilities may be developed by means of the permeating and co-operating processes which I have indicated; and thus those rare and exceptional experiences, which have till lately been regarded either as supernatural interferences, or as equally inexplicable illusions of the fancy, may ultimately receive a scientific explanation. I mean, that such phenomena as those now studied under the heads of hypnotism, suggestion or thought transference, telepathy, clairvoyance, and prevision, may be brought within the range of theories based on the biological hypothesis. Even the possibility of a future life after death may prove to be not beyond the limits of scientific speculation.

It is mainly this last named question, standing as it does in close connection with religious belief, which gives keenness to the interest with which rival theories of psychology are maintained and discussed. It used to be thought that materialism in psychology involved of necessity disbelief in a future life, and *a fortiori* in immortality. An immaterial soul was held to be a necessary condition of our surviving the death, and expecting the resurrection, of the material body. And, since no intelligible and independent conception of an imma-

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terial soul could be given, if followed, that belief in an immaterial soul and belief in a future life, or in immortality, became practically convertible terms; the one meant neither more nor less than the other. Our real and positive knowledge on this subject, therefore, is not affected by the kind of psychological theory which we adopt; on any theory our knowledge of this kind is *nil*, at least as the case stands at present. And as to knowledge possibly attainable in the future, there is an advantage on the side of the biological hypothesis; for this cannot negative the possibility, while it may conceivably confirm the probability, of a life after death, a probability to be founded, if founded at all, in the knowledge to be attained of living structures and vital processes.

CHAPTER III.

Results for Philosophy.

Book II. Ch. III.

§ 1. The Known and the Unknown.

§ 1. We have now seen what the general nature of Science is, to what kind of questions it contains an answer,— namely, questions concerning the order of real conditioning,—and with what kind of objects it deals,—namely, matter and consciousness, both being taken as real existents. Besides this a survey has been taken of the chief departments into which science is divided, and under which all its special branches may be distributed and classed. It remains to enquire what results are acquired for philosophy by the general facts concerning the nature, problems, and method of science, which have been thus brought out, and what conclusions we may take with us in returning, as it is proposed to do in the following Books, to the special questions of metaphysical philosophy. The harmony between positive science and philosophy, as well as the nature, value, and limits, of the contribution which the former makes to the latter, will thus be made evident.

I begin by mentioning some things which science does not and cannot tell us. The first is, How or why Matter comes to exist at all. Matter is the basis of all scientific explanation, and is taken by

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science as a fact which is given and indubitable, but the origin of which is unexplained. Yet inasmuch as it has a complex and analysable nature, and at the same time is not among the ultimate data of experience, it is something concerning which the question of real conditioning, which is the special question of science, cannot fail to arise. But this question, though it must logically be admitted to be inevitable, is always actually admitted to be unanswerable.

It is the same, whichever of its specifically different kinds, or the specifically different modes in which it is observed or inferred to exist, we select for consideration, namely (1) its mode of massive aggregation, in which mechanical interaction prevails, (2) its etherial mode, in which it underlies the phenomena of radiant heat, light, electricity, and magnetism, (3) its resoluble mode, in which its smallest known or conceivable particles exhibit the phenomena of chemical affinity, and (4) its organised mode, in which it is dominated by vital energies. True, the theory of Universal Evolution endeavours to prove, that all these different modes and energies of matter are derived, by real historical filiation, from some one fundamental substance and the mode of force or energy which it displays. But granting that this should have been successfully demonstrated, still that one fundamental substance, with its energy, would be as inexplicable as matter itself, being in fact nothing more than the special shape in which matter would have come into existence originally, and in which alone it would have existed for its first historical period. The existence of matter,

therefore, must at the best be inexplicable for science, whether we take it as a collection of groups, including all its varieties and modes, or consider it as existing in some initial state, out of which those varieties and modes have been developed subsequently.

There is another thing also which science must always find inexplicable, the nature of the other real existent which shares the whole field of positively known real existence with matter, I mean the nature of consciousness taken as a real existent. Whatever may be the case with other forms of existence, and even if vitality should be shown to have been evolved from non-vitalised matter, it is universally admitted that no corresponding evolution or genesis can ever be demonstrated of consciousness. The heterogeneity between vitalised matter and consciousness is a disparity too great to admit the conception that the one is a modification of the other.

I say this because, even when taken as an existent, consciousness has a nature of its own; that is, there is some *nature* which exists; and of this nature I say, that it is unexplained by anything in the nature of matter, though its existence in individual conscious beings, that is to say, the existence of particular consciousnesses, is explained by the existence of matter. Complete explanation consists of two parts, explaining (1) the nature, (2) the existence, of the *explicandum*; and only a nature can explain a nature, only an existence can explain an existence. For the first, some common feature or community of nature is evidently required, since without it all relation in point of

kind would be precluded. And to this extent, the old idea, that effects must be like their causes, has its grain of truth. Whether the idea of Evolution is scientifically justifiable or not, it is at any rate involved in the old and faulty common-sense conception of Cause. The operation of a Cause is an evolution, the efficiency of an existent and its nature taken together, drawn out into operation in time, in virtue of that nature.

Now consciousness as a positively known existent has a nature; we know it as a mode or modes of awareness,—sensation, memory, thought, volition, emotion, and so on; that is, we know it in forms which we class as so many psychological functions. That is to say, Processes of consciousness, distinct in point of kind, and dependent on some corresponding (though not similar) kinds of process in the Subject, are the way in which consciousness as an existent is known to us. The question is, how comes consciousness, when it comes to exist, to be *the kind* of existent which it is, namely, *awareness*, and awareness having specifically different properties and qualities of feeling, such as are those of the different senses, emotions, and thoughts? This which we may call the *nature* of consciousness, and of that same consciousness which we also call an *existent*, the nature of Matter does not explain.

Given the possibility of that nature, as something of which we cannot conjecture the real condition, then its first coming into existence as the consciousness of particular Subjects, and its development afterwards, as conscious functions of Subjects, may be shown to depend upon the exis-

tence and functioning of certain forms of vitalised matter, between which and consciousness there is a one-sided dependence but no re-action. In other words, the existence of human consciousness as a fact, and that in all the shapes and modes of it which are known in psychology, is explicable as the conditionate of certain functions of living organisms, but the nature of that consciousness, namely, the particular kinds or qualities of sentience or awareness (which terms I use to designate and denote its abstract essence), as well as that essence of awareness itself, is something totally inexplicable. All explicability implies it; moves, so to speak, within or upon it as its sphere or plane of being. Thus, of the two real existents which divide the world between them, matter is wholly inexplicable in point of origin, though explicable in point of nature by reference to those modes of consciousness which are our immediate experience of it; and consciousness, although explicable in point of origin, or *qua* existent, in particular cases, as the conditionate of matter, is inexplicable in point of nature; and that not only as found in particular human Subjects, but also, and still more obviously, when we consider the innumerable modes which, when unrestricted by human capacities, it may conceivably embrace.

The doctrine of Evolution, therefore, entirely fails to account for the *nature* of consciousness, though it may possibly be applied with success to account for the various derivative forms of matter and physical (including physiological) energy, because in the latter case there is homogeneity of ultimate nature in the physical world of real

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conditions. But there is a break or severance of this homogeneity when we come, as we come in psychology, to the second of the two great existents, namely, consciousness. It is impossible to conceive consciousness in its entirety, that is, as an existent of a particular nature, to be evolved from matter.—On the whole we must acquiesce in the conclusion, that both matter and consciousness, each taken in the concrete, are inexplicable by science, seeing that the real conditioning of both is unassignable, though for different reasons.

But perhaps it will be said, that it is absurd to demand an explanation either of matter or of consciousness, except so far as either can be explained by the other, being as they are the only two known ultimates in the realm of real existents; for by reference to what can ultimates possibly be explained? In this question I bring into notice a point which I particularly wish to make clear. The question of explanation, the question of the real conditions of matter and of consciousness, must inevitably and by logical necessity be put, when they are taken as real existents, that is, as particular components of the order of existence or real conditioning; which is the way in which they are taken in positive science, matter being then found to be subsumable under the general conception of real condition, and consciousness in the shape of the particular modes of it which are positively known to us, under that of real conditionate. And therefore, though they are the only ultimate objects positively known to us, they are not known to be the ultimate real existents in the Universe, in the sense of being unconditioned on

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any reality beyond themselves; indeed it is only by putting the question of real conditioning to them in common with other real existents, that we arrive at the discovery of their being, in point of fact, the only ultimates positively known to us. Consequently, they are not, and cannot be, known to exhaust, or be commensurate with, the whole order of real conditioning, of which they are conceived as parts. It would be an unwarranted and indeed an absurd assumption to suppose that Matter is the only real existent (in the full sense) in the universe, because it is the only ultimate real existent revealed, by means of physical energies, to a consciousness of a kind like ours, which arises in a particular kind of material structure, and the sensibilities of which depend proximately, for their coming into play, upon the energies of that structure, in communication with other energies of matter beyond it. Consciousness taken as a particular real existent in an individual Subject is a real existent of a particular kind, conditioned for its existence upon matter, which is a real existent of another particular kind; and to suppose that these two real existents exhaust the possibilities of real existence, or in other words, negative the actual existence of realities beyond themselves, is a logical absurdity, standing in direct contradiction to modes of perception and thought which are essential to consciousness itself.

The truth of this statement can readily be shown. Upon what rests the possibility of putting the question as to the real conditions of matter and human consciousness taken as real existents, at the same time that they are taken as ultimates of posi-

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tive knowledge? Upon the nature of consciousness as a knowing, which always perceives something, actual or possible, beyond any limit set by any particular perception, and consequently by any object of such perception. But matter and human consciousness taken as real existents are such particular objects or particular existents. It is the nature of consciousness as a knowing, that is, in its perception and thought, to transcend, that is, include an awareness of something beyond, itself, taken as a real existent, since this is a limitation of its content in a particular manner, and to perceive the fact of limitation is to perceive the fact of an existence beyond the limit perceived. In the same way it transcends matter, as a particular, that is, a limited, object of perception and thought.

Now the nature of consciousness, even as a particular real existent, that is, its essence as awareness, is, as we have seen, not conditioned upon matter. It is its existence, including its genesis, history, and development, as a particular existent, which is conditioned upon matter; and from this source its limitations also are derived; I mean its being limited to a certain number of sensibilities differing in kind. Therefore we must conceive, that matter gives rise to the existence of something which in its nature, that is, in the abstract quality indicated by its name *consciousness*, transcends its parent matter, and even itself in its character of dependence on matter, or, what is the same thing, as a particular existent possessing a certain limited number of sensibilities.

Is then the *nature* of anything separable from its *existence?* Is it so in the case of conscious-

ness? By no means. The two things are distinguishable but inseparable. If we cease to exist, we cease to think and to perceive. Our consciousness can be said to have a nature only so long as it exists. It is not, then, in the idea of the separability of the nature from the existence of consciousness, that we must seek for a solution of the difficulties, which spring from the unlimited character of the one, contrasted with the limited character of the other. For this solution I recur to the distinction between them, as it was set forth in Book I. (Chap. VIII. §§ 6 and 7). There we saw, that it is consciousness as a content, as a panorama, as a knowing, that is meant by its *nature;* and consciousness as a fact or *de facto* process, that is meant by its *existence.* It is unlimited in the former, limited in the latter character. The unlimited Universe is the object of its nature as a knowing; a limited organism is the proximate real condition of its existence. And limited as are both the number and the power of the sensibilities which it derives from its conditioning organism, they suffice to furnish it with elements and with forms, by which it apprehends not its own existence merely, but existence in its entirety, of which its own is but an infinitesimal portion.

The solution, then, is, that human consciousness, as it is positively known to us, is a process, and, as a process, stands necessarily in a double relation; that is to say, first, to its own content, which is perpetually being objectified in reflective perception, and secondly, to its real condition the organism. One and the same consciousness (and

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this is true also of every state or portion of that consciousness) stands in both these relations at once. Vision, for instance, is a process; the action of seeing is restricted to a seat in the organism; but the content or object of vision is an unlimited expanse and depth of space, of light, of colour. Thought is a process; the act of thinking is restricted to a seat in the brain; but it is an act which has for its object existence generally. In one brief moment vision sweeps the expanse of sky, and thought embraces millions of ages. Human consciousness is perception (including thought) in the forms of Time and Space, and has no limits but theirs. And neither in space, nor in time, nor in the number of kinds of objects which may be embraced in a single general conception, is there any limit possible to the things covered by human consciousness, notwithstanding its being the conditionate of a single limited human organism.

It is involved in its nature as a process of perception in the forms of time and space, that it should be unlimited in respect of its objective field, at whatever point, in time and space, it may be taken to begin or end, as a perceiving process. Being a process, it is a perceiving and a perceived at once. And the moment at which this double character, or double aspect, of the perceiving process is actually experienced is no other than the constantly repeated, or continually abiding, present moment of reflective perception, the analysis of which was represented, at the outset of Book I., as the key to the whole of philosophy. Thus the very same human consciousness, which is a parti-

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cular existent in relation to its real condition, the organism, is the subjective aspect of existence in relation to whatever parts of its own content have been, or are from time to time, objectified by reflection; among which objects are included those which are thought of as real conditions, as well as portions of objective thought. The moment of reflective perception, which is the moment of actually experiencing or being conscious, is at once the subjective aspect of existence, and also in relation to one of its own objects, namely the organism, is an existent conditioned upon the organism, and may be perceived and inferred to be so, when itself objectified in subsequent moments of reflective perception.

What becomes, then, of the apparent contradiction, which gave rise to the question we are considering? It entirely vanishes. So far from the unlimited nature of human consciousness being in contradiction to its limitation as an existent dependent on the organism, it is inseparably bound up with it. Limited as a function of the organism, it is unlimited in the content which as a knowing it embraces. And not only so, but then only can we understand its limitation as so dependent, or as the function of an organism, when we return upon it, as it were, from the exercise of the function, the consideration of consciousness in its entirety, and endeavour to determine the nature and position of living organisms capable of consciousness, by reference to other parts, other objects, and other processes, which fill or constitute the total panorama of our objective thought. Briefly, then, in this double relation of our positively known human

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consciousness, we have before us, and may now perhaps better understand the significance of, that often-insisted on distinction between consciousness (1) as the subjective aspect, or objective thought, of all things, including modes of consciousness of which we can form no positive idea, and (2) as the conditionate of an organism in which it is seated.

It is at this point, that is to say, with the conception of consciousness as the conditionate of certain functions of living organisms, which is the fundamental conception of physiological psychology, that positive science may be said to return again into metaphysical philosophy, with its results in hand; just as in Book I. it was shown how it logically issued from the philosophical analysis of the phenomena of experience, with its problems before it. Those results may be briefly summarised as consisting in the definitive substitution of the scientific conception of consciousness as the conditionate of organism, for the common-sense conception of an immaterial Self, Soul, or Mind, which is merely a refinement of that empirical total, the Conscious Being.

The significance of this result for philosophy is very great. It for ever deprives it of that *a priori* conception or idea, which, under such names as those of The Divine Mind, or The Great First Cause, it has for centuries used as an hypothesis adequate to the comprehension or construction in thought of the whole unknown region of the infinite and eternal Universe, as well as of that region of it which is within the range of positive knowledge. Note, however, that it is not the idea of the Divine Being or Divine Majesty, but the conception of

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Self, Soul, or Mind, as a conception expressing or interpreting it, which thus makes default. This is another instance of a cherished conception of ordinary human intelligence breaking down as a scientific conception, before the advance of scientific and philosophic thought; a conception cherished because it seemed to flatter the imagination, that we can by thinking find out God, or compass, by means of human ideas, an *a priori* knowledge of the infinite universe of being.

For the true object of philosophy is indeed the whole universe of being, the whole panoramic content embraced by human thought; but it is not that universe composed (by pure assumption) of one or the other, or both together, of the two existents Matter and Mind. Taken without assumptions the universe consists, as we have seen, of two parts, the relatively known and the relatively unknown; in which total, the known world of matter and the conscious beings dependent on it are but an infinitesimal speck. We thus know something even of what we call the unknown region. The important point to notice is, that what we know of it is always and necessarily in the form of *a knowing*, not of an existent object known. We cannot see or think of the object of it as we can see and think of matter and material conscious beings. Our knowing is indeed itself an existent, being part of our really existing consciousness, but in respect of its objects, or so far as it is part of the subjective aspect of existence, it is a knowing only. We cannot confront it with any other knowledge of its objects obtained by an independent channel, as we can confront concept with percept in the case of

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material objects. We know something which we must hold true of *whatever* existents may really occupy the unknown region. We have objective thoughts which we cannot but apply to it, though we have no independent grasp, or positive knowledge of the objects thereby thought of. Our knowledge of objects thought of, other than thought itself objectified by reflection, does not go beyond matter and its conditionates, matter being the first and only real condition positively known to us.

This, however, leaves between the known and the unknown worlds a wide margin open for the possible advance of positive knowledge. The line of demarcation is not fixed, but extensible within certain limits. It may include within it whatever can be brought, by inductive or deductive methods, into dependent connection with modes and forces of matter. The limit consists in the knowledge of real conditions, however that knowledge may be acquired. And with our present powers, as we have seen, the only objects which we can positively think of as real conditions are material. It is when we attempt to transcend this limit that we go wrong in philosophy, as in science.

With regard, then, to what we have called the unknown region of the universe, the general result of the foregoing reasoning is to substitute in theory a world of real but not positively known conditions and conditionates for an absolutely unknowable existence, imagined either as the cause of the known world, or as the noumenal reality of which the known world is the phenomenal manifestation. These latter conceptions are practically equivalent

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to restricting reality to the known world, with its two kinds of real existents. For they supply no means of conceiving the connection between the known and the unknown, but leave them in contrast, one as natural, the other as supernatural. The conception of real conditioning on the contrary applies to and includes both worlds, being nothing more than the conceptual mode of stating the fact, that everything which is positively conceivable, without exception, has antecedents and co-existents, without which it would not exist when and where it does exist. This conception is plainly not itself altered or transcended, by being applied to the connection between the known and the unknown; it is simply the positive conception of the real existent or existents in the unknown region, thought of under the conception of real condition, which makes default. Both the known and the unknown are conceived as parts of one and the same system, equally real, equally subject to uniform laws of Nature. The unknowability of the unknown world thus becomes a relative unknowability, relative to the limited range of human sensibilities, and due, not to that world being above natural law, but to ourselves not being sensitive to its agencies. Nothing, as it seems to me, can well be simpler than this way of looking at the matter, which is directly founded upon the methods and results of science, when brought into comparison with those of philosophy. The conceptions of cause and self-manifesting noumena, on the contrary, are conceptions drawn from the common-sense form of experience,

ambitiously put forward to do duty as philosophical explanations.

§ 2. Design in Nature.

§ 2. The mischief done by the conception of Cause does not stop at the bare relation between the known and the unknown. There is a variety of it which is constantly applied within the field of positive science, the conception of Final Cause, otherwise known as End, Purpose, or Design in Nature, and supplies the basis of what is called Teleology. Given the conception of Cause as an efficient agent or agency, then that of Final Cause is a modification of it, by including in addition the reason, or motive which guides its efficiency into this or that channel, or determines it to effect this or that result. A Final Cause may therefore mean either the reason determining an efficient cause, or the efficient cause as determined by a reason. In both cases alike it is a conception taken directly from the common-sense form of experience, and built upon the analogy of human voluntary action, as construed thereby.

Now in Nature as made known to us by positive science, the facts are innumerable which readily lend themselves to an interpretation of this sort, and they are facts which admit of no doubt. Both the organic and the inorganic kingdoms of Nature are full of instances which can only be described as harmonies between one structure and another, harmonies between structure and function, harmonies between one function and another, harmonies between antecedent and subsequent actions, precisely analogous to what in human operations is taken as evidence of preconceived purpose or design. Nor is this confined to the

world of living beings, or to their relations with their non-living environment. The mutual adaptation of parts, and regular interchange of energies, in the mechanical, physical, and chemical dominions, give to the whole material world the appearance of a Cosmos, and make its ceaseless action seem like the result of a calculated mechanism. So that, to adopt Aristotle's expression, Nature seems everywhere to work for a purpose, just like man. Summing up these facts, which as facts are indisputable, under the name *apparent design*, let us see what justification there is for interpreting them as due to a Final Cause; which in other words is asking, whether the design apparently displayed in them was really pre-existent in the shape of a plan, reason, or felt motive of any kind.

I confine myself, of course, to considerations founded on what has been said in the two foregoing Chapters. And in the first place I remark, that if we surrender the conception of a Cause existing in the unknown world, we necessarily surrender with it that of a Final Cause existing in that world. But on this I do not mean to insist. Nor again do I intend to lay any weight on the fact that, if either a Cause or a Final Cause exists in the unknown world, in any way determining the known, its existence must *ex hypothesi* be incapable of direct verification. This does not need saying, and yet we might conceivably have valid grounds for inferring their existence (always supposing them to be something logically construable to thought), grounds drawn wholly from experience of the known, just as we have grounds

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for inferring the existence of the unknown reality itself.

The way in which this question is usually treated is to begin by assuming, that preconceived design is a *vera causa*, in a large and well-marked class of human actions, and then to consider whether or not such harmonies of unconscious Nature as those indicated above warrant the inference, that preconceived design was a necessary cause or con-cause in bringing those harmonies into existence. Sometimes it is argued, that a conscious intelligence must have existed in the unknown world as the producer, and still exists as the sustainer, of the known world of Nature. Sometimes a distinction is attempted between conscious and unconscious intelligence (as if the latter were not a contradiction in terms), and an unconscious intelligence is inferred either in the known or in the unknown world, or in both, as the explanation of the harmonies to be accounted for. But in every case the basis of the argument consists in the assumption, that what is called the human Mind acts from some felt motive, or for some preconceived end. The supposed fact that it does so supplies at once the basis of inference and the conception of the thing to be inferred, namely, the operation of final cause or causes in Nature, as distinguished from the agency of man. Without the supposed purposive action of the human mind, we should never have framed the idea of the efficiency of final causes.

I am not going to criticise any of these arguments, nor can I even treat the question in the same way. What I have to point out is, that

they have no *locus standi* at all. Their common basis of argument is a fiction. So far from there being final cause in Nature, which is their common inference, there is none in Man, the assumption of which is their common premiss. What is called conscious purpose in human voluntary actions is an *explicandum*, not a fact which can be taken as a ground of explanation. The human mind, as we have seen, is something which belongs to the common-sense form of experience; something, therefore, which requires analysis. Before we can proceed to argue from its actions to those of Nature, we must first analyse its actions. If, on analysing its actions, we find that they are done from preconceived design, or from previously felt feeling, well and good;—we shall then have at least a basis for arguing, *pro* or *con*, concerning the attribution of similar action to known or unknown Nature; but not otherwise. What, then, does analysis show?

We saw in the Section on Psychology in the foregoing Chapter, that states and processes of consciousness were concomitant phenomena, dependent upon nerve action, but never really determining links in the chain, either of nerve actions *inter se*, or of actions between nerve, organism, and environment. They were, on the contrary, dependent upon those physical nerve actions of which they were the concomitants, and consequently were not real determinants of one another. At the same time we saw, that in many cases they were our only means of designating and speaking of the nerve actions upon which they depend. We therefore describe the whole action

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by the consciousness which is its concomitant and dependent part. Thus, when we say, *I think, I feel, I remember, I desire, I choose, I resolve, I purpose, I act*, and so on, there is involved in each case a nerve process, and this process, which is not expressly described, is included in the act which is described, as a whole, by any of the terms in question, these being terms of consciousness. And the real agency lies in this undescribed nerve action, which is not affected by the concomitant consciousness which is used to indicate it.

In order, then, to obtain so much as a basis for an argument attributing final cause to Nature as distinguished from man, it is requisite first to show, that states or processes of consciousness, as in cases like the above, are really determining links in the chain of human actions. Until that has been done, no such argument has a *locus standi*. By which, of course, I mean no place or basis in scientific or philosophical reasoning; for no one disputes that human beings act purposively and from preconceived design, when the statement is made simply as a common-sense description of facts, and makes no claim to be taken as analytically accurate; just as no one disputes that *the sun rises* is true as a common-sense statement, which is not intended to assert that the movement is in the sun. Philosophy based on unanalysed notions of common sense is a contradiction in terms.

Supposing, however, that we have happily escaped from the meshes of the common-sense philosopher's net, we are not on that account in possession of any theory of apparent design itself. The

common-sense philosopher argues on the assumption, that apparent design in human action is real design. To disprove this assumption is but to leave the problem of explaining apparent design, both in human actions and in Nature generally, just where it was before the common-sense philosopher had spun his cobweb. Far be it from me to discourage speculation. Nevertheless I think, when all is said and done that can be, the roots of apparent design will be found in that small group of ultimates, spoken of in the foregoing Section, of which no account can possibly be given beyond the relation which they bear to other ultimates. I mean that the phenomena of apparent design can be traced back to the nature of Matter, of which in their rudimentary form they are an inseparable feature, and that in consequence of this they share the final inexplicability of Matter itself. If this view is correct, the explanation of apparent design belongs entirely to science, and consists in tracing every instance of it back, through processes of simply efficient or *de facto* conditioning, to the ultimate constitution of Matter, and to the action and re-action between its parts. A two-fold result; for on the one hand final causes would be wholly eliminated from all scientific explanation, while on the other, apparent design, being involved in the very constitution of matter, would be left standing as an ultimate fact of Nature, scientifically inexplicable.

But now briefly to set forth the grounds of this conception. It has been shown above, that all matter occupies space, and that matter and force mutually involve each other. Every portion of

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matter, therefore, is a structure occupying space, and having correspondent parts. On such a basis it is not difficult to see how those results supervene, which bear the appearance of design. For when we compare two states, former and latter, of a structure having correspondent parts, each of the two states by itself consisting of correspondent actions and re-actions, then, if there is any marked correspondence observable between the two states, they will seem to make part of a single whole; and therefore, since this whole exists only as a sequence in time, it will also necessarily seem as if the latter state had been foreseen, and the former state designed with reference to its production. If the former of the two states has meaning prior to the existence of the latter, it can only be because the latter is foreseen as its consequence. But such a meaning we read back into it, when once the latter state has supervened. Thus while the marked correspondence gives the appearance of unity to the process from state to state, the fact of its being realised only by a process in time gives the appearance of prevision. As when, for instance, a seed becomes a plant, and the plant produces a seed again. The seed seems to be for the sake of the plant, and the plant for the sake of the seed; or, again, the plant for the sake of the plant, by means of the seed; or the seed for the sake of the seed, by means of the plant. Or take the wonderful transformations of insects, from egg to larva, pupa, and imago which lays eggs again; the insect in many cases performing, in one state of its being, actions minutely and curiously adapted to the wants of its next

state; wants of which it is impossible to suppose that it has a prevision, and actions which it performs but once in its life-time.

In short apparent design is correspondence, whether the correspondence is noted in structure only, or between structure and function, or between structure and structure by the way of function, or between former and latter structure and function taken together. In cases involving sequence, there is a *de facto* correspondence between the former and the latter state, just as there is a *de facto* correspondence between the simultaneous parts and actions of each state severally. And moreover the latter state, with its simultaneous correspondences, is a result of the former state with its correspondences; it represents the work done or the energies displayed by the parts and actions of the former state upon each other during the time terminating in the latter state. But there is no more design, in the sense of preconceived plan, in the latter state than there was in the former. Each state consists of correspondences, and the former is a real condition of the latter. The latter is a conditionate of the former, but not its *final cause*.

On a basis of this kind it is permissible to make the freest use of the facts which are described as instances of design in Nature. They are often of the highest service in framing hypotheses. They are not the less *de facto* sequences and co-existences because denied to owe their existence to preconceived design. The real marvel is not that the functioning of material structures yields

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instances of apparent design. The real marvel is the existence of structured matter.

Briefly stated, my position is this. Before we can adopt the thesis of Design in Nature, we must first distinguish apparent design as the *explicandum* from really preconceived design as its *explicatio*, and this being done, we must then show, that really preconceived design is operative as an efficient condition of apparent. Explaining anything means, in positive science, referring it to the real conditions by which it comes to exist. The thesis of Design in Nature means, that really preconceived design is not only a *vera causa*, but also a *vera causa* of apparent design. But even the preliminary distinction of real from apparent design is not often explicitly drawn by upholders of the thesis. Still less do they succeed in showing that the former is a *vera causa*. Positive reasons for this failure have been adduced above.

§ 3. Apparent Design.

§ 3. There is, then, no such thing as Design or Final Cause in that order of real existence, or real conditioning, which we commonly call Nature. No preconceived design is ever a real condition contributing to determine the course of events. But, as we have also seen, this does not affect the real existence of what I have called apparent design, consisting in the observed correspondences which as a matter of fact result from the operation of physical energies in uniform ways. Something still remains to be said in elucidation of apparent design as a real phenomenon, now that we have seen it rescued from confusion with final cause, and are no longer in danger of regarding the latter as a real determinant of the course of Nature.

And in the first place, what is the *differentia* which leads us to distinguish it at all from the *de facto* correspondences in which it consists? Why do we notice it and give it a special name? The reason must lie in the pleasure or gratification which the correspondence yields. It interests us. But different correspondences may interest us in all sorts of different ways, and for all sorts of different reasons. There is, however, a special kind of interest attaching to the observation of a correspondence of parts, simply as such. There is a gratification in the mere fact of correspondence, distinguishable from, though inseparably bound up with, other features in the facts which correspond to one another, whether these features are in themselves gratifying or the reverse. We feel correspondence preferable to non-correspondence.

But in the next place, this preferability lies wholly in consciousness as distinguished from its real conditions, and from the real conditions of the correspondences to which it attaches. Apparent design is preferable as compared to contents of consciousness which do not exhibit it, or exhibit it in a less degree. As it has not been ideally present in its real conditions at all, it cannot have been compared by them with other contents of consciousness, or conceived by them as a possible and preferable alternative. This in fact would be making a final cause of it. At the same time it is inseparably connected with the real conditions on which it depends. Without them it would not exist, though, when it exists, it exists in consciousness alone.

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The case is closely analogous to that of real conditions themselves, as described in a former Chapter. The relation of condition and conditionate, it was observed, does not *as such* exist in Nature at all. Certain relations of co-existence and sequence are found existing in Nature, and these we bring under our conception of conditioning. The things which exist in these relations we call conditions and conditionates, indicating thereby, not anything in Nature itself, but our own way of regarding Nature, namely, that without the occurrence of the one, the other *would not* occur. For there is nothing answering to *would* or *would not* in Nature, but only *de facto* occurrence or non-occurrence.

Similarly with apparent design. A certain kind of preferability, in some contents of consciousness compared to others, is the characteristic denoted by that term. But there is no preferability in Nature, meaning thereby the things which we call real conditions as distinguished from consciousness. At the same time, we can justify our sense of preferability by appealing to the play of real conditions, and the real correspondences resulting from them, precisely as we can justify our conception of real conditioning by appealing to the real coexistences and sequences which the conception expresses. And the preferability in the one case, and the conditioning in the other, are then, as it were, reflected back, from consciousness, upon the existence of the actual *de facto* order, just as, to take a more rudimentary instance, colour sensations are reflected back from consciousness, and attributed to the tangible objects from which the

rays of ether vibrations are transmitted to the eye. Apparent design is therefore read into the really efficient part of the order of existence from consciousness, just as possibility, alternatives, conditioning, and the secondary qualities of matter, as they are called, are read into it. All alike are real and demonstrable, though not real in the full sense of being efficient real conditions. They are parts of our panorama of objective thought, but not parts of the World of Matter as a real existent in the full sense, contradistinguished from it. And the same will probably be found true of what we call *Necessity* in Nature, namely, that it is a determination belonging to our objective thought only; its real correspondent, or object thought of, in the world of Matter being neither more nor less than *de facto* Universality.

Supposing this reasoning to be correct, it is manifest that apparent design must attach to the whole and every part of our known world, though merely in their character of objects thought of, corresponding to objective thoughts, not in their character (where it exists) of real conditions, nor as in any way contributing to their efficient or determining power. Every object thought of exhibits correspondences, in virtue of that character merely, and not because Nature is an order or process of real conditioning, nor even because some of its correspondences are found in sequence and not in co-existence. The simple fact of correspondence between parts is irrespective of whether the corresponding parts are in co-existence or in succession, or of their standing to one another in the further relation of condition and conditionate.

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Simple correspondence of parts, in which apparent design consists, is a pre-requisite of real conditioning, whether this is conceived as a relation of succession or of co-existence. We cannot think of anything as a real condition, without first thinking of it as a real object thought of. For, without this, the character of being a real condition would have no content to which it could attach, but would be a mere abstraction imagined as an entity. This point was made abundantly evident in Book I.

Now it is to this pre-requisite of real conditioning that apparent design attaches; that is to say, to our whole known world and all its parts, simply in their character of objects thought of. And this being so, and apparent design being thus the necessary pre-supposition of all real conditioning which is positively knowable, it follows that we are thereby precluded from the possibility of discovering how or why apparent design itself comes to exist. It is possible, and indeed inevitable, to put these questions, because we necessarily conceive the known world, not as self-existent, but as a part of a larger whole, the universe of existence; but it is impossible to answer them, because the remainder of that larger whole, beyond the limits of apparent design, must either be taken, *ex hypothesi*, as entirely unknown, or else, if taken as in any way known, must then be taken, at least, as an object thought of, and in that character as already including apparent design. We can no more answer the questions,—How or Why there is apparent design in the known world, than we can answer the questions,—How or Why the known world itself exists.

When, however, we quit the consideration of apparent design in this its utmost generality and simplicity, and come down to particular cases of it, cases for the most part in which real conditioning is involved, and in which, therefore, antecedents appear as means leading to consequents as ends, and questions arise concerning the comparative desirability of ends, we then find ourselves introduced to complications, from which most of the intricacy attaching to the subject of apparent design originates.

We have seen that the interest of apparent design proper, or in itself, is of one special kind only, being simply the preferability of order to chaos, of intelligibility to unintelligibility. But the correspondences in which we take this special kind of interest are also correspondences which interest us in various other ways, and for a great variety of other reasons. None of these have really anything to do with apparent design. Any other interest which we feel in an object, over and above the fact of its exhibiting a greater or less correspondence of parts, is an interest which we take in it, not as a case of design, but as an object which gives or tends to give us some more particular satisfaction, or procure us some particular relief, or answer some particular question with which we are concerning ourselves,—all of which are ends of a more personal kind, and pre-suppose a more specific character in ourselves as percipients, than the comparatively colourless gratification of simply perceiving a correspondence.

The neglect of this distinction is a fruitful source of confusion in thought, and ambiguity in

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language. In considering the world as exhibiting design, we often imagine that what does not harmonise with our own estimate of what is desirable cannot exhibit harmony at all, or that what does so harmonise must have formed part of the general scheme of Nature. Or if we are fully prepared to accept the verdict of facts, and welcome results which make against our most cherished desires or ideals, provided only they are Nature's truth, we still not unfrequently imagine Nature to have drawn distinctions which in reality are devised by ourselves as modes of questioning her, and to be favouring one class of the objects so distinguished at the expense of another.

Now it is true, that design proper is an interpretation of Nature having a psychologically subjective origin, namely, interest; but it is not true, that what we feel to be the highest or best interests, nor even the interests of any class of existents which have been singled out as of special importance by scientific thought, must necessarily be those which Nature will either presently or ultimately realise. Nature works just as man works, in point of always and inevitably harmonising part with part, and antecedent with consequent; but it does not follow that Nature works as man imagines himself to work, that is, guided by preconceived distinctions and purposes, still less by those which man would have imagined to be the truest and the best.

The difference to which I have just drawn attention, I mean between the special kind of interest which is the *differentia* of apparent design and interests of all other kinds whatever which guide or influence our judgments, affords a line of demar-

cation which should never be overlooked. Judgments of apparent design proper belong to speculative or theoretical reasoning; judgments based on any other kind of interest to practical. Both kinds have one root, and that a subjective root (psychologically speaking), in common; I mean that both spring from interest, but diverge according to the kind or nature of the interest from which they spring. There is no difference in preferability between different cases of apparent design, provided the correspondence is equally clear, equally complex, and equally complete. It is when we come to variety of interests that we come to varieties in kind of preferability, that is to say, interests which give rise to judgments of the second class.

Now there can be no rational objection to our comparing things with reference to their kind and degree of preferability, ranging them in various scales, and assigning them different rank, in a teleologic hierarchy, so long as we frankly recognise that the classification is due to ourselves, by reference to our own interest, and does not represent a preconceived design on the part of Nature. But to recognise this is to recognise, that, in framing such a teleologic scale, we are not discovering, but ourselves arranging and instituting, that is, exercising not speculative or theoretic but practical reasoning; practical, of course, not in the sense that we are therein actually choosing what we already know or think to be best, but in the sense that we are considering and deciding in our own minds what we are to judge best, as the first and necessary step towards

actually choosing or endeavouring to effect it, if and when an occasion should offer; considerations and decisions which we may subsequently apply to judge the actual worth or value of the real world of Nature, according to the degree in which it lends itself to the realisation of our chosen ideals or purposes.

For consider in the next place what happens, when, in human action, we proceed to the question of realising any end or interest thus judged to be desirable. We are then referring it to its real conditions, that is, to the means of realising or effectuating it. But in so doing we return to judgments of the first order, though less general than before, that is, to judgments of speculation, theory, or discovery of fact, as distinguished from practical judgments, or comparison of particular preferabilities. We leave the consideration of degree and kind of preferability, and restrict ourselves to the question of the real foundation in Nature of the feelings or objects which we prefer, or in other words, of their real *de facto* conditioning, and therefore of their comparative attainability. This question is plainly one of a quite different order from that of comparative preferability, notwithstanding that results acquired by means of it may profoundly affect our judgment of comparative preferability, belonging to the other order. The one is a question of *ought* (in the wide sense of the term), to be settled by a comparison of states of consciousness *inter se;* the other is a question of *fact,* to be settled by a knowledge of the laws of real conditioning. The probability of our being able to attain, or ourselves to effectuate,

what we judge desirable is a special case of the probability of its occurrence in general. And our estimate of the probability of anything occurring or not occurring depends on our greater or less knowledge of those laws, whether operative in ourselves or in external objects, just as its really occurring or not occurring depends on the laws themselves.

Lastly observe the results of this distinction. We have in consequence of it three several heads or classes of judgments;—first, judgments of apparent design in the proper and strict sense, which are speculative or theoretic judgments of what Nature *is*; secondly, judgments of comparative desirability of ends, which are teleologic or practical, but express man's teleology or practice, not Nature's; and thirdly, judgments of means or conditions necessary to attain whatever we regard as ends, whether our own or Nature's; which judgments are again speculative or theoretical, but are not judgments of design at all, being merely a discovery of the *de facto* order of real conditioning.

Confusion of thought most commonly arises in attributing ends belonging to the second head to Nature, and then, in consequence, imagining that the real conditions which realise or tend to realise them are employed by Nature as means, either consciously or unconsciously, but in either case involving the idea, that a future end actually governs the selection of present means. Whereas, in truth, the correspondences constituting the apparent design of the first head, and the *de facto* order of real conditioning, which pre-supposes it, of the third head, are all that really belongs in any

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way to Nature's agency, as distinguished from man's. It may indeed be said, that we may consider future ends and present means together as a single whole, in which ends and means seem calculated for one another; and this is true; but then, by so considering them, we destroy the priority of design to effectuation, reduce the whole to the rank of an object thought of, and have before us a case of apparent and speculative, not human and practical design. The term *apparent design* is used to describe certain correspondences, both of co-existence and of succession, which are actually found in the Course of Nature, by reference to the common-sense conception of design in human actions. The explicit insertion of the word *apparent* saves the phrase from being a misleading one. Not so when, without any similar safeguard, we speak of means employed to realise non-existent ends in Nature. No special ends, and consequently no means to effectuate any, can be truly attributed to that play of real conditions, in which the efficient action of Nature consists.

In conclusion, it is necessary briefly to apply the conceptions of the present Section to the case of the known world itself, considered as a whole consisting of the two real existents, matter and consciousness, the latter being the conditionate of the former, in respect of its existence. The correspondence between these two parts constitutes the whole which they compose a single complex object thought of, exhibiting apparent design, and having the special value due to that special kind of interest. Taking the parts severally, matter, as *conditio existendi* only, has no value or preferability

of its own; whatever value it has is reflected back upon it, from the nature of the consciousness which it conditions; which nature (as distinguished from its existence) is, as we have seen, not conditioned either upon the nature or upon the existence of matter. Consciousness alone, and in its nature alone, is the source of all judgments of value; since it is only as applied to consciousness itself that the term *value* has any meaning.

At this point, opinions as to the value of the world as a whole will inevitably become divergent. The reason is, that at this point we pass from the consideration of design proper to judgments of comparative desirability, which are judgments of the second head noted above. The experience of each individual will here decide his opinion, both as to the comparative value of different modes of consciousness, and as to the desirability or undesirability of his own existence as a conscious being; and therefore, derivatively, as to the value of those modes of matter upon which his existence depends. It need not be pleasure and pain in the ordinary sense, by which these judgments are determined. Some may think that even a painful consciousness is preferable to none; others, that pleasure alone is worth having. But in every case, our judgment of the value of existence, and of the world in which we exist, is suspended ultimately, not upon the existence, but upon the nature of consciousness. The fact of value, or interest, generally is not the reflex of anything in matter. Even the special interest taken in correspondence simply is different from, and additional to, the perception of the correspondence as a fact.

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The value of a fact is different from its existence, different from its perception. With the feeling of value, or interest, in general, the affective life, as distinguished from the life of sense, may be said to begin. And all value is founded in the nature of consciousness, of which no conditions are conceivable.

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§ 4. These considerations bring us back again to the point from which we started at the beginning of Book I., the double aspect of consciousness or experience, (1) as process-content, (2) as existing fact. But now we return to it from and after the consideration which at first we postponed, namely, that of genesis and history. So much as this we can now affirm with certainty about consciousness, namely, that its genesis and history as a particular real existent, and in the shape in which we actually know it, I mean, in the shape, for every one of us, of an individual's consciousness, namely, his own, are conditioned upon matter. And of matter we know, that it is a real existent, positively known to us both as a real object thought of, and as a real condition, and known by means of the nature or process-content of that very consciousness, the real existence of which it conditions.

The distinction upon which this knowledge immediately depends is that between objective thought and objects thought of. A real condition is a real object thought of, and both its real existence and its real operation are objects of inference. We can therefore conceive them as existing prior to and independently of the individual consciousness which is their conditionate, while at the same

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time the conception and act of inferring them exist as part of the consciousness which they have conditioned and continue to condition. Moreover, consciousness is always retrospective, even when states of consciousness are its only objects. We need not therefore be surprised that it should continue to be retrospective, when inferred realities are included among its objects.

We return, then, to philosophy from the domain of science, which has been the main subject of the present Book, enriched with the conception of real conditioning, both in the world at large, and in the case of individual conscious beings, and also with the conception of these latter as partial realisations, or, if I may so speak, partial productions into positively known existence, of modes belonging to the infinite nature of consciousness, that nature including modes or features which are positively unknown to us, as well as those positively known modes or features, some of which we began by analysing.

At the same time it is clear, that neither in that analysis, nor in the present consideration of genesis, have we overstepped the limits of experience, as existing in individuals and as positively known to us. This indeed we have done,—we have seen what and where are the limits of positive knowledge. They are the boundary between the known and the unknown worlds, but lie within the total panorama which our consciousness embraces and perceives as its object. There are beyond them, in the unknown world, existences which we must conceive, according to the modes of thought belonging to the known region, (1) as

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real conditions of the structure and existence of Matter, and (2) as a continuation of the known modes of consciousness by or into modes of which we can frame no positive imagination or thought. But we cannot put the question of real conditioning concerning the nature of consciousness, as we can put it concerning the structure and existence of matter. In the case of consciousness, therefore, what we must conceive as lying beyond the limits of the known is not any real condition of its nature, but other modes of consciousness itself, which, supposing them to be made part and parcel of our own human consciousness, would disclose a panorama of other real existences, which at present lie, as it were, behind an unuplifted veil. And thus these unknown existences are thought of, not as noumena which as they are *in themselves* are inaccessible to knowledge, but as phenomena objective to other modes of consciousness than ours, and knowable by those modes just as much, though probably not in the same way (namely by way of inference) as we know material existents, which are not consciousness, but are the inferred objects of it.

Nor can we help regarding the facts in this way. We cannot but think of the existence of the unknown, because the known is limited; and we cannot but think of it as connected with the known, because the conception of a limit presupposes the conception of something lying immediately beyond it, no limit being absolutely ultimate. It is the positive content of the unknown which makes default; and in this default it is, that what is called its unknowability consists. It is unknowable by our limited range of sensibilities, and by ideas and

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combinations of ideas derived from them. For these, as we have seen, allow us positively to picture no kind of real condition but one, and that one is matter. But from this limitation it cannot logically be inferred, that no other real condition but matter exists, or that matter is co-extensive with real existence in the full sense of the term *real*. In other words, the existence of a world of real conditions, other than matter, among which would be found the real condition or conditions of matter itself, is logically and necessarily conceived as a reality or real existence, though the conception is not positively verifiable, and though we have no other means of laying hold of and designating that real existence, than the empty and anthropomorphic general term *real condition* itself.

The enlargement, or rather the filling up, of the panorama of consciousness, beyond the limits of the known, by the addition of new kinds of sensibilities must, then, be conceived as possibly bringing new kinds of real conditions into our knowledge, just as our present range of sensibilities gives us a knowledge of that material real condition, upon which its own genesis as human consciousness, in individual conscious beings, depends.

This would be different, if *(per impossibile)* the nature of consciousness, as well as its genesis in individuals, was conditioned upon matter. In that case consciousness would be wholly dependent upon, or evolved out of, matter; and whatever new kinds of sensibilities might be developed in it would point to no kind of real condition other than the old. Matter could then be logically regarded in no other light than as the sole ultimate reality, the

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self-existent and unconditioned source of all things. It would be, in Scholastic phrase, the great First Cause. But note also, that at the same time this conception of it would be self-contradictory. For how could matter, which, as we have seen, is susceptible of analysis, both subjectively as a mode of objective thought, and objectively as the cohesion of parts actively and adversely occupying space, be conceived also as unconditioned, except in the sense, that its real conditions are unknown to us? Conceiving it as the sole ultimate reality involves conceiving it as a necessary existent, and yet, on the other hand, the possibility of this conception is precluded by our knowledge of its composite nature. It would therefore have to be represented as contingent and necessary at once, which is impossible.

I see but one way to avoid falling into this contradiction, consistently with maintaining the reality of matter, and that is the way which I have always taken in this and former works, namely, to distinguish the nature of consciousness from its genesis as an existent in conscious beings, and to suppose its nature independent of matter. This latter supposition is based directly on the fact, that matter and consciousness are essentially heterogeneous, the characteristic difference, or specific essence, of consciousness being awareness or sentience, while the absence of this characteristic is essential to matter, from our conception of which, whatever else may be included, we always and at any rate exclude awareness or sentience. For this fact, seeing that consciousness and matter in conscious beings meet in the closest union, seems

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susceptible of no other interpretation than is afforded by first distinguishing, in both cases alike, *nature* from *genesis*, and then conceiving that, in point of nature, consciousness is independent of matter, notwithstanding that matter is the immediate condition of its arising as an existent, at particular points of time and space. Plato's well known distinction between genesis and nature,—ἓν μέν τι γένεσιν πάντων, τὴν δὲ οὐσίαν ἕτερον ἕν, (*Philebus.* 54.A.)—is thus in some sort the logical key-stone of the system which I have now once more sketched, considered as a logical structure. It is so, when applied, as I now apply it, to the analysis of consciousness itself. The nature of consciousness is one thing, its genesis another; its nature having no conditions of any sort or kind, and its genesis meaning the fact of particular modes of it coming into existence in particular instances, that is, in particular individual real beings.

Perhaps it will be said, that the application of this distinction is arbitrary, and though possibly legitimate as an aid to thought, yet points to no real difference in the world of reality. A word or two will show the nullity of this objection. The distinction is one which not only may, but must be applied in thought to everything without exception, because it is based on a difference which is found in everything without exception. Everything, consciousness included, has duration and exists in time. Consequently, in everything, its existence or place in order of time and its existence as such and such a content must be distinguished from one another. We must know *what* it is which has place and duration.

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Now in applying this distinction to consciousness and to other things, this further difference discloses itself, namely, that all other things, and among them particular states and processes of consciousness itself, have genesis as well as nature; that is, they have a beginning in time. Consciousness alone, but only in its nature, or in other words, the nature of consciousness alone, or consciousness as a knowing, which is commensurate with its entirety, has no beginning in time, and consequently no genesis. And for this ultimate reason, that time-duration is an inseparable element in the nature of consciousness, being that formal element which is indispensable to it, and contributes with the equally inseparable material element, or quality of its feeling, to constitute that nature what it is. Consciousness, therefore, in its nature, shares the infinity of its formal element, time, as well as the multiplicity of its material element, feeling. And this inseparable combination, and nothing else, of time-duration, as the indispensable formal element in the nature of consciousness, with differences of feeling in its material element, gives rise, and cannot but give rise, both to the perception of particular objects, or particular states of consciousness, coming into existence, or having a beginning in a pre-existing time, and also to the perception which is implied and involved in it, that for time-duration itself no beginning is possible. Thus we see how it is, that consciousness in its nature is all-embracing, having for its opposite aspect Being, or Existence in its widest sense, including the existence of consciousness itself, and possible existence as well as actual; all things

else being either particular concrete objects, or else abstractions which have no separable and independent existence.

Moreover it is evident, that this all-embracing and infinite character of Knowing, or of the nature of consciousness, is not due to any logical process of conception or thought, although it is of course true, that conceptual language must perforce be used in describing it. I mean, that the nature of consciousness, or consciousness taken in its nature alone, does not owe its all-embracing and infinite character, which in one sense of the term may be called its universality, to its being the object of a generalisation, the object named by a general term which has logical universality, and embraces as its particulars either the consciousnesses of all possible conscious beings, or the innumerable modes of consciousness of one or all such beings. To hold a view of this sort would be to assume, that we already know, to begin with, what particular conscious beings, or what particular modes of consciousness, as distinguished from their objects, are, before putting the question *what* to consciousness or experience simply, by which alone such knowledge can as a fact be actually acquired. That is, it would involve reversing the only true and specifically philosophical method. But what we have now seen, by following that philosophical method, which is subjective, and analytical, and makes no assumptions, is this, that the nature of consciousness, as distinguished from its genesis and from its history in individuals, is a single thing, with a single definite meaning, in whatever conscious being it may exist, namely, knowing or

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perception in the form of time, and is therefore (always taking it in its nature and not as an existent) infinite as time is infinite, and unique as Being is unique, of which it is the knowing or subjective aspect. The various actual or possible modes of it, which are innumerable, are parts within it as a perceptual whole, not species or varieties under it as a logical whole; and it is itself plural only when taken as an existent, or as existing in individual Subjects.

The consciousness, therefore, of every individual Subject has the same nature, the same infinity; but the richness of content of that infinite nature is different in each individual. The same infinite universe of Being is the object of all alike, but each perceives it after its own measure of endowment or capacity. The consciousness of each individual Subject is necessarily separate from that of every other; but then this is consciousness taken in its existence, not in its nature. The consciousness of an individual Subject, which should be the adequate knowing of the infinite universe of Being, that is, be an individual and yet omniscient consciousness, is for us an ideal which we can never positively conceive as realised, inasmuch as we cannot conceive either infinite Being, or infinite Knowing, as at once complete and infinite. At the same time, it is an ideal which involves no logical contradiction, seeing that both Being and the Knowing of it may equally and alike be conceived as infinite, though neither can be conceived as at once infinite and complete.—A finite intelligence is one which is restricted to move by taking one part after another in exhaustion of a whole, which at

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the same time, and at every step of the process, it knows or may know to be inexhaustible. An infinite intelligence cannot be conceived as restricted to work on these lines. For us, therefore, such an intelligence is an ideal, the type of whose activity we have no positive means of conceiving. For us to conceive positively an individual consciousness or intelligence is to conceive a finite and existent one. At the same time, to embrace infinity is characteristic of the nature of consciousness, because time-duration is an essential element of its nature.

This cannot be said of genesis, nor of any particular existent which pre-supposes it, such for instance as Matter. All genesis supposes a limit introduced into Being or Existence in the widest sense, which is the object of consciousness in the widest sense, a limit at or after which the thing generated begins to exist. Consequently all genesis presupposes an eternal existence, an existence having a wholly unlimited duration, *eternal* meaning that of which no ultimate limits in time are possible, or their possibility conceivable,—compared to which everything else has a finite duration, that is to say, is either preceded or followed, or both, by something not itself. And the moment we consider things as having a finite duration, preceded or followed by other things, that is, as particular existents, the question,—How or Why they come to exist,—immediately arises, which is the question of the real conditions of their genesis.

It is thus impossible to conceive the nature of consciousness, or consciousness in its entirety, as a particular existent. Which is saying in other

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words, that consciousness as a whole can never be identified with anything short of eternal existence, and with that only in the character of its subjective and commensurate aspect, not by way of undistinguished union. Awareness (using this term as a brief expression for the entirety of its nature), if taken as *being* the whole of existence would be awareness of nothing; and the possibility of distinguishing one content from another, in point of reality, would be taken away. It is only some particular nature or other which can be conceived as a particular existent. And no particular nature, no particular mode or combination of modes of consciousness, the human for instance, is identical with the nature of consciousness in its entirety. It can be only to this or that particular nature, this or that mode of consciousness, that the questions of genesis and real conditioning apply. But to these they apply necessarily and inevitably, so soon as we take them in respect of their existence.

There is, then, nothing arbitrary in the use now made of the distinction between nature and genesis. For, first, the distinction is applicable to everything without exception, and secondly, when applied to consciousness, in forcing us to recognise, that consciousness in its nature is essentially different from all things else in their respective natures, it does no more than make explicit that indispensable minimum of difference, within otherwise unanalysed and undifferentiated experience, which alone endows the term *knowledge* with any fixed significance. Consciousness taken in its nature alone, in which respect it is the wholly unconditioned source of knowledge, admits of no genesis from what is not

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itself. In this latter respect it is paralleled only by its own inseparable objective aspect, Existence or Being, likewise considered in its utmost generality. It is only within the limits of consciousness and existence generally, as opposite aspects of each other, that genesis of anything takes place; whether it be of particular modes of consciousness, or particular modes of existence other than consciousness, but known as objects of it; or whether it be of individual consciousnesses as particular existents, or of particular existents from the nature of which consciousness is excluded, but upon the existence of which the existence either of individual consciousnesses, or of the modes of consciousness belonging to them, is immediately conditioned.

§ 5. The Conscious Being.

§ 5. Once more recurring to the fact that, in the opening chapters of Book I., the process-content of consciousness, as we actually experience it, was distinguished into two parts or aspects, its content and the fact of its being perceived, its *whatness* and its *thatness*, the latter being at once the fact and the evidence of its existence, we see that what has been done in the present Book is to account for its *thatness*, or the fact of its being perceived, by referring it, as an existent, to nerve structure and process in living organisms, as its proximate real condition, and by showing, in general terms, the connection between living organisms and other less complex forms of matter, thereby making it evident that matter, in some form or other, embraces all the real conditions which are or can be positively known to us.

In this way we have brought into view a different object from consciousness distinguished

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simply into its two aspects, *whatness* and *thatness*. We have now before us the conscious being, the object of psychology, a concrete real object, consisting, so to speak, of two moieties, a system composed of real conditions and their conditionates, the organism and its consciousness, bound up together. The agent and the agency proximately concerned in consciousness are thus added to consciousness taken alone, with the analysis of certain parts of which, considered as a knowing, we were busied in the preceding Book. The agent of consciousness and the proximate real condition of consciousness are one and the same thing. But it is with the thatness of consciousness, or (what is the same thing) with consciousness as an existent, not as a knowing, that they stand immediately connected; being connected with consciousness as a knowing, which is the philosophically subjective aspect of it, mediately only, through its existential character. It was made, I hope, sufficiently clear in the preceding Section, that the nature of consciousness, as distinguished from its existence, was wholly unconditioned upon anything whatever.

Consciousness as an existent in individual conscious beings is thus, psychologically speaking, the subjective half of the whole object-matter of psychology. It is not immediately with our knowledge, but with the genesis and history of our knowledge, taken as itself an existent, that psychology has to do. In what remains of the present work, in the following Books, I propose to return to the analysis of consciousness in its philosophically subjective character as a knowing. But inasmuch as more complex cases of consciousness

will then present themselves for analysis, cases of reasoning, volition, and emotion, in which the true nature of conscious action as distinguished from consciousness simply, will be the main point of interest, it will be seen why I have thought it necessary to present some clear idea of the real agent and agency at work in them, before proceeding to analyse them as states and processes of consciousness, at once evidencing the actions on which they depend, and reflecting their own value and meaning upon them.

A few more words in explanation of this position will be necessary, before proceeding to the proposed analysis. If the conception of causal efficacy or power as an entity or reality, distinguishable from the *terminus a quo* called Cause, and from the *terminus ad quem* called Effect, and mediating between them, had been legitimate, and if consequently there had been reason for supposing it possible to discover the nature of causality *per se*, then (but then only) the following question would have been legitimate also,—To what part of the whole conscious being causality belonged? So that by analysing the action of that part we might reasonably expect to discover the nature of the causality exercised by it. Some might expect to find it seated in nerve or brain, others in an immaterial soul or mind, others in an Ego, others in a faculty such as the will, or the "thinking principle," others again in states or processes of consciousness itself, as in thoughts or imaginations, and others perhaps even in unconscious, latent, or possible consciousness, or finally in a combination of two or more of the things mentioned. And if

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on investigation it should turn out not to be discoverable in any of them, then seeing it was (by supposition) the object of a legitimate conception, it might fairly be regarded as a real though not phenomenal entity or agency, having a real but inaccessible existence in a noumenal world of Things-in-themselves.

But these speculations and the controversies springing from them, which many persons find so attractive, are forbidden and precluded by the fact, that causality *per se* is a conception belonging to the common-sense form of experience, and has no scientific or philosophical justification. It is an experience which we have to explain, and not one which serves as the basis of an explanation. To raise the conception of it, as Kant did, to the rank of an unconditioned Category of Thought, prior to experience, and necessary to render experience itself possible, is a wholly unwarranted assumption, or rather set of assumptions, which, in whatever form it should be made, would suffice to vitiate any philosophy which admitted it. As a common-sense experience, on the other hand, it is obvious and unmistakable. If, for instance, two persons, A and B, quarrel, and A in a moment of anger so far forgets himself as to kick B downstairs, then A has an unmistakable experience of being the cause of B's descent, and B an experience equally unmistakable, of his descent being caused by A. That is an instance fairly exemplifying the common-sense conception of causality. But it is in vain to search in it for anything like causality as a power *per se*. All cases of common-sense causality resolve themselves, on analysis, into cases of *post hoc, cum illo*,

evenit istud. Hence we say, that the search for causes is given up in science and philosophy, and replaced by the search for real conditions and the laws of real conditioning, laws which in every case are ultimately classifiable, as was set forth in the foregoing Chapter, under the two heads of Configuration and Motion in matter. This substitution involves and expresses the surrender, on the part of philosophy and positive science, of the conception of a noumenal world of Things-in-Themselves, as a true and valid conception; and no psychology which does not frankly adopt this view has any claim to be considered a positive science.

But more is requisite to its frank adoption than merely renouncing the search for causality *per se* as impracticable. It must also be recognised, that realities answering to the terms cause and causality *per se* are impossible and non-existent. For otherwise the things belonging to the phenomenal order of existence are reduced to mere appearances, dependent on cause and causality as inscrutable noumenal realities, and the uniformities which they exhibit cease to be conceivable as laws of action of any real forces of Nature. Another world, and that a wholly inconceivable one, is set up over against the phenomenal one, as the only true Reality, and thus the attainment of any true knowledge (which is the sole purpose both of science and philosophy) *ipso facto* precluded.

Now whatever may be the existences of the unknown region, behind the veil figuratively spoken of above, it is clear that they are not things answering to the terms cause and causality *per se;* for these express mere conceptions of common sense,

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which, so far from explaining anything, have no claim to be regarded as scientific or philosophical conceptions at all, much less to be raised, as Kant's hypothesis raised them, to the rank of *a priori* forms of a supposed transcendental Subject, known as Categories of the Understanding, without which experience would be impossible. The non-existence of cause and causality must therefore be recognised, as well as their inscrutability by human science. And real conditions and conditioning must not only be sought for by science, but must be sought for *vice* cause and causality deceased.

From this it farther follows, that, in positive psychology, it is requisite to adopt some definite hypothesis, as to what kind of real conditions are operative. Is latent consciousness, for instance, or consciousness below the threshold of consciousness, to be considered a real condition? Is a Self or Ego a real condition? Is a Mind, or Soul, or Spirit, a real condition? Is any specific Function *per se* a real condition, such for instance as Thought, Conception, Judgment, Imagination, the Will, the Reason, Instinct, Desire, the Affective or Emotional nature? Are feelings or thoughts of specific kinds, pleasure and pain for instance, whether of sense, emotion, or intellect, or the idea of the Good, real conditions determining, or contributing to determine, the phenomena of consciousness? Are nerve and brain real conditions or not? Whatever our choice of an hypothesis may be, some definite conception with a positive content must be given of the thing or things selected as hypotheta, before any theory, or even any enquiry, founded upon it can have any claim to be a theory or

enquiry in positive science. This is no new necessity. All positive science seeks to discover the laws of natural processes by referring them to positively defined substances or agents. The requirement of positively defined hypotheta as conditions of processes, or the logical demand to have it clearly stated, *of what* they are assumed to be processes, is not altered by the fact that causality *per se* is recognised as an empty notion.

Some psychologists there are, who endeavour to evade this requirement by alleging that causality *per se* is undiscoverable, while they carefully avoid declaring it an empty notion. They urge that in no case, either of physical or mental processes, can we discover the real nature of the process itself, or of the agency which operates therein; that we know only *phenomena*, and that real or *noumenal* operation, which is causation, is hidden from us; from which they argue that, in psychology, the enquiry into the real conditions and the laws of real conditioning of consciousness is to be given up, or at any rate left to metaphysicians, a term which in their use of it means transcendental ontologists. Their argument rests on identifying real conditions and conditioning with noumenal causes and inscrutable causation, a mistake, the fallacy of which I need not again demonstrate. In their eyes, '*that which*' definitions are good enough for psychology. And they use the doctrine of the inscrutability of noumenal causation to escape from the necessity of committing themselves to any hypothesis as to the real but phenomenal conditions of consciousness.

In the hands of psychologists of this stamp, the form which psychology takes is not that of an

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enquiry into the real conditioning of consciousness, based on a previous metaphysical analysis of its phenomena, whereby what is meant by its being *really conditioned* is discovered; it is that of an examination, or what may be called a psychological analysis of its phenomena, assumed and understood as belonging to individual conscious beings, and referred to some psychical cause residing in them, the real nature of which, and of its connection with its phenomena, is regarded as inscrutable. The phenomena are then classed, by means of their similarities, as belonging to such and such functions (*faculties* was the old word) of the assumed conscious being; the laws or general facts of their sequence and co-existence, composition and recomposition, ascertained and recorded; the fact noted of the definite correspondence and concomitance of states and processes of consciousness with nerve and brain processes in the conscious being, though all assertion of their dependence upon the nerve and brain processes which accompany them is studiously and often expressly avoided; while, as already said, no hypothesis whatever is hazarded, as to the real nature of the assumed psychical agent in the conscious being, or of the mode in which it produces its phenomenal effects.

A more futile method than this can hardly be imagined, as the method of a positive science. It is one which would only be legitimate when no further possibility remained to us of framing any positive conception of the real conditions of consciousness, and when all hope of making psychology a positive science had consequently been abandoned. Disregarding, or perhaps unacquainted with, the

distinction between consciousness as the process-content of a knowing, and consciousness as a real existent, it proceeds on a complete misconception of the point to be proved. That point is, not how the states, elements, and processes of consciousness, composing an individual's common-sense experience, may be best discriminated and classed as belonging to distinct functions or modes of operation, the supposed play and interaction of which result in such an experience, but how these states, elements, and processes of consciousness are actually brought into existence, and how they come to take the place and hold the relations which they do, to others in their actual context. This, it is evident, requires the adoption of some positively conceived hypothesis as to the real condition or conditions on which they depend, and not merely the assumption that some real condition exists, in or behind the supposed functions under which they are grouped, and on the nature of which their uniformities of sequence and co-existence, when discovered, may be represented as likely to throw some indirect light.

Any guidance which the above mentioned distinction might afford is wholly neglected by the method in question. It professedly begins by being simply analytic and descriptive of the process-content of consciousness, like those parts of our metaphysical method which dealt with the first acquisition of the experience of real Subjects and Objects, prior to drawing the distinction between the panorama of knowledge, or objective thought, and consciousness as an existent. And so long as this line of thought is strictly adhered to, it is obvious

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that we do not get beyond the limits of metaphysical analysis, or the purely descriptive branch of the subjective half of psychology. Nevertheless, after discriminating the various component elements of that process-content, the method goes on to classify them, or assume them already classified, as elements belonging to various mental functions, such as sensation, perception, apperception, retention, memory, association, recollection, attention, thought, judgment, emotion, appetition, volition, reasoning, and so on, all of which, simply as functions, imply the existence of some real agent, since no function is intelligible without one.

Now it is a great leap from consciousness conceived simply as process-content, in which its nature or *whatness* only is considered, notwithstanding that sequences and co-existences are included in it, to consciousness conceived as function of an agent, that is, as a conditionate of some other real existent. The two conceptions belong to two disparate, though connected, orders of ideas. It is impossible to pass from one to the other in any way whatever, without going through the intermediary conception of a real Subject, and impossible to do so in any way which is scientifically fruitful, without also framing some positive idea of that Subject's nature. But such an idea or conception of a Subject, agent, or proximate real condition of consciousness, which is necessary to constitute a psychology of any kind, can only have been attained in the first instance by treating consciousness as a knowing, that is, by noticing *what it tells us*, undistinguished as yet from itself as the

teller, and therefore can only be justified, if at all, by metaphysical analysis, which is the analysis of it in that character, now at length explicitly distinguished. Psychological analysis, in any definite sense, has no existence until this idea has been attained, or rather justified, by metaphysical. In short, since it is only as function of a positively conceived Subject, that consciousness becomes the legitimate object-matter of psychology, it is only by metaphysical analysis that any positive conception or idea of a Subject, having consciousness as its function, can be ascertained as valid.

It is therefore to metaphysical analysis, whether avowedly and *eo nomine* or not, that psychologists must have recourse to verify the conception of the Subject, and prove its reality. Just as the reality of matter as conceived by physicists, so also the reality of the Subject of consciousness as conceived by psychologists (and that whatever their conception of it may be) is a question for metaphysic. Newtonians and Berkeleyans alike must anchor here. And it may be added, so also must those who, as thorough-going Idealists, would establish the unreality alike of Mind and of Matter, that is to say, would establish the exclusive reality of the process-content of consciousness itself.

The only alternative course for psychology is to adopt some *a priori* assumption, which so far as its own so-called analysis goes there is no justification for its making; and this is the alternative which too many psychologists prefer at the present day, apparently for no other reason than to render their science independent of philosophy, which it can never be so long as it has any claim to

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be a positive science. Thus it is, that the true question of psychology, namely, the discovery of the laws of the genesis and history of consciousness as an existent, in dependence on its real and positively known Subject, is neglected, and questions of so-called psychological analysis, *plus* the unjustified assumption of an agency not positively known, are substituted in its place, or rather perhaps in place of that metaphysical analysis which is its true pre-requisite and foundation.

The true question of psychology, which concerns the real conditioning of consciousness, depends upon, and is forced upon us by, the course of actual experience, in the manner which it has been attempted to describe above. It was shown that the knowledge of consciousness as an existent, that is, an existent of a special kind among existents of other kinds, arises by putting the question *How comes?* to certain portions of the panorama of knowledge as distinguished from other portions, and finding them to be located in the Subject's organism. Psychology is the following up of this special track of thought, specialised out of general metaphysical analysis, by putting the question *How comes?* to consciousness as distinguished from what we afterwards call other objects and the Subject. It is in vain to expect, that falling back upon general metaphysical analysis will answer any questions which arise solely by departing from it. For to answer those questions they must be kept distinctly in view, and to keep them in view is to depart from the general and enter upon the specialised track.

There are three main processes of consciousness as an existent, in which the necessity for some

positive hypothesis as to their genesis is more especially prominent. They are those of sense-perception, spontaneous redintegration or association of ideas, and volitional modification of either. In the case of sense-perception it is evident at once, that no merely metaphysical analysis of consciousness will account for the occurrence, here and now, of an unexpected sight or sound in the sequence of its states, the occurrence, let us say, of a flash of lightning, or the striking up of a barrel organ in the street. To account for the occurrence of the sense-perceptions which we call by the name of these objects, we must have recourse to the hypothesis of a real Subject in a world of real objects.

Not quite so obvious, but quite as imperative, is the necessity for appealing to some cerebral agency in accounting for trains of spontaneous redintegration, say for instance, for the flash of lightning recalling into consciousness the idea of the heavy patter of rain-drops, or for a tune played on the barrel-organ recalling the image of some far-off incident of past life. The so-called laws of similarity and contiguity in states of consciousness are no explanation of such recall actually taking place; there must be some permanent mechanism by which it is effected, over and above the congruities observable between the states of consciousness, named the recalling and the recalled, when it is effected. This will be shown in greater detail in a future Chapter.

Thirdly, the occurrence of volitional re-actions upon sense-perception or upon trains of spontaneous redintegration, so as to modify the process-

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contents of consciousness composing them, requires the supposition of some real agency, over and above the features included in the consciousness which is re-acted on and in its modification. It is here that the agency of a supposed immaterial Self or Ego is commonly introduced, a being who behaves in the first place as a passive recipient of sensations and their mechanically produced associations, and in the next place as what he is supposed to be in his real nature, a self-conscious agent, active in remoulding what he receives for ends or purposes of his own. It is as if a replica, or rather miniature, of the real Subject as thought of by common-sense, an invisible duplicate of the conscious being, was hurried up to the apex of every reflex channel of nerve communication subserving conscious action, on occasion of every stimulus received either from without, or from other parts within the brain. I am not now criticising this hypothesis. I merely allege it as showing how universally the necessity is felt, for having some positive hypothesis as to the real agency at work in volitional action, in contrast with the theory that the analysis of consciousness as process-content is all that is required in psychology, and tells us all that we can reasonably expect to know of the agency concerned in it.

On the whole then I argue, that, since it is impossible to avoid introducing real conditions into psychological enquiries, it is better to do so avowedly than surreptitiously ; and that, having done so avowedly, then it is also imperative to select such as can be definitely and positively conceived as real. These requirements are plainly

fulfilled by the real conditions of consciousness which I have adopted in the present work, namely, nerve and brain structure and function,[1] it being clearly understood, that they are adopted solely in the character of real conditions and not of causes, that is to say, not as accounting for the nature of consciousness as well as for the genesis and development of particular modes of it.

The living nervous system is that part of the organism which, in man and all animals in which it is distinguishable, governs and as it were animates the whole, renewing the energy of the parts to which it is distributed, and directing their action, both within the organism itself, and in its action and re-action with the external world. At the same time, in certain of its parts and functions, it immediately subserves consciousness, and gives unity of development to the conscious life of the individual. Its connection with other parts of the organism, as well as with consciousness, is immediate; with the outer world mediate, through other parts or tissues of the organism. Its task is two-fold, physical action on the one hand, subserving consciousness on the other. It is the nervous system which is really described by the popular and figurative terms, *soul*, *mind*, *spirit*.

Considering it in the first place as simply subserving consciousness, apart from its re-action through the organism upon the external world, the fact must never be forgotten, that even here it is a

[1] But not adopted, I may perhaps be permitted to observe, in the present work for the first time. My full adherence to the doctrine was first given in my *Theory of Practice*, 1870, Book I. Chapter III. §§ 49 and 57 (Vol. I. pp. 335-344 and pp. 416-436), to which I should be glad if readers would refer. I had, however, gone a long way towards it five years earlier, in my first philosophical work, *Time and Space*, 1865.

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physical substance, exercising living physical energies, upon the action of which consciousness immediately depends. These, and not the agencies coming from without the nervous system, are the proximate real conditions of consciousness. "Every external excitation," says Professor Delbœuf, "acts on the soul by transforming itself into a physiological excitation. It is not light which affects the soul, but the modification of the nervous system, of the retina if you like, under the action of light. But the retina is not in itself an inert substance; before receiving the action of the luminous rays, it is already subject to a physiological action, resulting from the very life of the individual. The physiological action produced by the external light then comes in *as an addition* to this internal cause, and it is the sum of these which must be considered as the true source of the sensation."[2]

The broad fact thus indicated by Professor Delbœuf, I mean the broad fact of the two sources, external and internal, which combine their forces in the nervous system of the Subject to produce and mould sensation (for this is what we must understand him to mean by acting on and affecting the soul), this fact he then proceeds to lay at the basis of his admirable criticism and re-construction of the Psychophysical Law originally but not satisfactorily formulated by Fechner, in dependence on the law of the relation of sensation to stimulus known as E. H. Weber's. The explanation of many facts are derived from it, as, for instance, those of the degeneration of sensation in intensity,

[2] *Examen Critique de la Loi Psychophysique, sa Base et sa Signification.* 12mo. Germer-Bailliere et Cie, Paris. 1883. p. 31-32.

owing to the accommodation of the organ to stimuli coming from the environment; the phenomena of fatigue, sense of tension, uneasiness, pain, and their opposites; as well as the determination of the circumstances under which vividness and clearness of sensation attain their maximum. But with all this we need not here concern ourselves. The broad fact, which is the basis of the whole, is alone essential to our present purpose.

The essential point of primary importance to physiological psychology involved in Weber's and Fechner's law of sensation, as well as elsewhere, is well brought out by Dr. A. D. Waller in that part of his work on Human Physiology where that law is expounded: "Having learned that the relation between stimulus and sensation is such that equal increments of the former cause diminishing increments of the latter, we are naturally led to ask whether the transforming factor occurs in physiological or in psychological territory. Is the material sensificatory brain-change proportional to the external stimulus, and the sensation some geometric function of that change, *or* is the material change itself a geometric function of the stimulus, and attended with sensation in direct proportion to its own magnitude? Fechner and Wundt subscribe the first alternative, to the effect that the transforming factor is psychological, *i.e.* between the sensificatory change and the sensation. Pfeffer, Delbœuf, and others, hold that the disproportion is physiological, *i.e.* between the stimulus and the sensificatory change."[8]

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[8] *An Introduction to Human Physiology.* By Augustus D. Waller, M.D., F.R.S. 2nd Edition. Longmans. 1893. Part II., Chap. XV., p. 550.

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The essential importance of this point is, that the truth of the former alternative would almost inevitably compel us to adopt the idea, that either consciousness, or some immediate and immaterial agent of it, was a real factor, a real condition, acting and re-acting upon and with nerve substance in all cases of sensation. If, on the other hand, the latter alternative were the truth, we should not indeed have positive proof that no such immaterial agency was present, but inasmuch as no sign of its presence would be manifested where, if anywhere, it might be expected, we should at any rate have a strong confirmation of our present hypothesis, that the whole real conditioning of the occurrence of states of consciousness is of a physical character.

Now there is some experimental evidence forthcoming, that the latter alternative is the true one. Since the passage above quoted was published Dr. Waller has instituted experiments with a view to determine this among other points concerning the Weber-Fechner law, a description of which with their results he has embodied in a communication to the Neurological Society, the substance of which is published in BRAIN.[4] I cannot here transcribe the details of the experiment which bears upon the present point. I must say, however, that it was not one in which any separate estimate of changes in sensation could be obtained, but was confined to comparing the successive increments of external stimulus with the corresponding increments of activity produced by them in the sense-organ operated on. Nevertheless the

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[4] *Points relating to the Weber-Fechner Law: Retina: Muscle: Nerve.* BRAIN, Parts LXX. and LXXI. Summer and Autumn Number, 1895, pp. 200-216.

experimenter, after re-stating the question contained in the passage which I have just quoted, gives it as his opinion, that, in consequence of its result, "our judgment must be strongly inclined towards the second alternative" (p. 205); that is to say, towards the alternative, that the change of proportion between the external stimulus to a neural organ of sense and the sensation which is concomitant with its neural action due to the external stimulus, takes place between the external stimulus and the neural action, and not between the neural action and its concomitant sensation. To this extent, therefore, our present hypothesis is confirmed.

Returning to the general current of the subject, I think it may be said, that three things are requisite to the arising of any, even the lowest and simplest, state or process-content of consciousness. First there is the unconscious normal, or (in case consciousness has already been aroused) the superinduced and momentarily existing, phase of action in the nerve substance subserving the consciousness. Secondly there is an interruption of this phase, in the shape of a stimulus imparted from elsewhere, whether it be from a source external to the nervous system, or from some other part or organ within it. And thirdly there is the re-action to this stimulus in the organ receiving it, the resultant of the two, within the nervous system, being that action upon which the newly arising state or process-content of consciousness immediately occurs. The *minimum* of nerve life and action, when subserving consciousness, must contain at least these three factors combined in a resultant

neural action. And the simplest or smallest organ or portion of nerve substance, whatever it may be, which is the subject of this *minimum* of action, may be conceived as the *minimum* organ of consciousness in its lowest terms. It is conceivable that a single nerve cell should be such a *minimum* organ. But practically it will be more serviceable to imagine a system, say of two cells, peripheral and central, functionally connected by means of a nerve fibre or fibres, or a system of two central or intracerebral cells similarly connected, and standing to each other in a relation analogous to that between centre and periphery, as the *minimum* organ subserving consciousness. A stimulus imparted from without to either of the cells in such a system will then be transmitted to the other; from this latter a re-action will begin; and a state of consciousness will result, of which the system formed by the two cells with their connecting fibre or fibres may be considered as the seat. The interruption of the normal, or of the momentary, phase of action in a nerve system, by a stimulus coming from beyond it, and calling forth a re-action on its part, will thus be the normal condition of a feeling or a state of consciousness; and the greater the difference in strength between the normal, or the momentary, phase of action, and the stimulus interrupting it and arousing it to re-action, the greater will be the vividness of the resulting consciousness.

The re-action of a relatively internal or central on a relatively external or peripheral factor is thus a *sine qua non* condition of the genesis of consciousness in a nerve system. But a different and

additional re-action, exercised by the same nerve system or part of it, comes into notice, when we consider the nervous system as animating the organism in its motor re-action as a whole upon its environment. In this relation of organism to environment, the *minimum* of nerve life and action consists, first, in reception of impressions already described from beyond the nerve structure, in which we have just seen that a certain re-action is involved, and then, consequent upon this, in a re-action of the nerve substance upon some non-neural part of the organism, which stands in immediate connection with the world without; the receptivity being the condition of sensation, though not always or necessarily involving it, and the second or motor re-action being determined by the original or acquired structure and properties of the nerve substance, at least as much as by the stimulus from beyond it. This *minimum* we may conceive, not only as an artificially distinguishable element or factor in the life of a developed conscious being, but also as constituting, or having constituted, the lowest stage in a phylogenetic development of living beings, of whom man is the highest. In man the two functions are represented (1) by a number of highly developed organs both of special and systemic sensation, and (2) by a number of nerve centres and fibres, which excite or inhibit motion in muscles and other bodily tissues.

Now as new modes of sense or receptivity (to speak only of receptivity which normally subserves sensation), and new modes of motor re-action consequent upon them, were gradually and severally developed in nerve structure, during the ages

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which have intervened between its primitive and its present stage of existence in man, the nerve structure in which they were developed being the common agent exercising both functions, it is necessary also to suppose that new modes of intercommunication were developed *pari passu* between the added organs of sense or receptivity, which thereby became active and re-active with and upon one another; and also new modes of their reaction, as parts of an organised whole, upon the added modes of motion and inhibition of motion, imparted to the body in consequence of them. In this way there has come to be superposed, upon the primitive organs of sense and motion, a mass of structures, the function of which is to mediate between the newly developed organs of sense, which receive impressions directly from the body or external world, and the newly developed channels which impart motion directly to the bodily organs. Speaking generally, the functions of this whole mass of intermediate organs are (1) to elaborate the impressions received from organs of the one class, and (2) to govern the motor impulses transmitted by organs of the other, in accordance or harmonious continuity with that elaboration. Three distinct functions in place of two are thus performed by the whole developed and undivided system.

This description applies to the whole mass of intracranial nerve structures, the greater part of which is devoted to the intermediary functions of elaboration of impressions and governance of motor impulses in accordance therewith. Its organs are strictly sensor only when and so far as they are

occupied in receiving impressions immediately from the body or from the external world. And strictly motor only in conveying the final re-actions of the intermediary nerve system to muscles and other tissues. Their own proper internuncial action may be called quasi-sensor and quasi-motor; it is that which I had in view above, in speaking of cells which stood to one another in a relation analogous to that between centre and periphery. These cells, or the group which they compose, are representative and associative, not simply presentative, of sensation. They are immanently not transeuntly operative of motion. Their proper action and re-action is between themselves. Their proper operation is upon the centres of transeunt action, or action beyond the limits of the nerve structure. In one word, they are the organs of the redintegration, both spontaneous and voluntary, of sensory impressions, and of the combination and adjustment of the nerve forces which issue in muscular movements.

The quasi-sensor and quasi-motor functions, then, of this whole intracranial group of organs are the features by which we distinguish it as a group from the organs of sense proper and of motion proper, both of which have, in many cases, their central terminations within it. The fact that these terminations are within it prevents our distinguishing the organs so sharply as we distinguish the functions. The intracranial group is strictly sensor, so far as it actually receives presentations from nerves of sense, and strictly motor so far as it actually imparts motor impulses to nerves distributed to muscles and other tissues of the body.

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It is the preponderance of the mass devoted to representative and associative functions, by means of added zones of structure brought into intercommunication by tracts of internuncial fibres, which justifies us in calling the group, as a whole, redintegrative and elaborative, quasi-sensor and quasi-motor, notwithstanding that it contains organs which receive sensations and transmit motions in the strict and proper sense of the terms. Each strictly sensory organ, or group of organs, localised, let us say, in the cerebral cortex, is representative as well as presentative or strictly sensory. Each ultimate motor nerve centre, similarly localised, let us suppose, in the cortex, is receptive of some stimulus, as well as originative of the motor impulse. And this partial identity of organs, with difference of functions, is precisely that feature which secures the unity of the entire system.

That this must be so, will be evident on careful consideration. The *minimum* of nerve life, even apart from its re-action upon the non-neural parts of the organism, and through them upon the environment, involves the fact of doubleness of function in singleness of organ. Every, even the lowest, nerve centre is both receptive and re-active. In this doubleness of property it does but repeat on a higher platform, that of the most highly organised matter known to us, the very same phenomenon which we found present in every particle of inorganic matter, namely, the phenomenon of *vis insita*, called out by, and exercised as, *vis impressa*. In psychology the consequence follows, that there is no such thing as an organ

devoted exclusively to a single function. There is no motor organ or group of organs, in the cerebral cortex or elsewhere, which is not also either sensor or quasi-sensor, that is, receptive of nerve impulses from other sources. To conceive otherwise would be to conceive the motor organ so isolated as a *first cause* of motion in the Scholastic sense.

Thus we read in Dr. Waller's work already quoted: "The 'sensori-motor' conclusion is, indeed, an inevitable one; any motor or discharging centre must also be a sensory or receiving centre; it must be excited as well as excite. Any 'sensory' centre must also be motor, directly or indirectly; else we could have no objective tokens of sensation; every centre, whether called motor or sensory, is *terminus ad quem* as well as *terminus a quo.* Hughlings Jackson from the clinical standpoint particularly insists upon the 'sensori-motor' character of all centres, as opposed to the crude conception of 'motor' centres, and in his hierarchical schema of central nervous mechanism represents sensori-motor centres in three grades—(1) highest-level centres (the præfrontal cerebral cortex), (2) middle-level centres (the Rolandic cerebral cortex), (3) lowest-level centres (the pons, bulb, and cord)."[5]

Another point in connection with the foregoing may be noted. It is in vain to look in the nerve mechanism for organs or groups of organs corresponding to the common-sense distinctions of faculties of the mind, such for instance as Memory,

[5] *Introduction to Human Physiology.* 2nd Edition, p. 543. I break off the quotation somewhat abruptly, omitting Dr. Waller's remarks on this classification of centres, which would lead me too far from my main purpose. I would refer my readers also to a valuable article by the same author *On the Functional Attributes of the Cerebral Cortex,* in Brain. Double Number containing Parts LIX. and LX., 1892, pp. 329 to 396.

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Apperception, Appetition, Imagination, Thought, Understanding, Reason, Will. These are names for groups of conscious processes or conscious actions which are classed together for no other reason than their similarity in experience, irrespective of any knowledge of the source or real condition from which they arise, and consequently of their possessing any local unity or single organ corresponding to the similarity. There is no single or exclusive seat of self-consciousness, or perception of the Ego. In whatever process-content of consciousness we recognize unity, and connection with other contents, that we *ipso facto* perceive as *ours*. It is an instance of the fallacy of making entities of abstractions, when such groups as these are attributed to a retentive or recollective power, a self-conscious power, an attentive power, an imaginative power, a desiring or emotional power, a thinking principle, or a will, as single powers of the mind. This indeed many persons are ready to admit. But it is also no less a fallacy, when they are attributed to single and several seats or organs in the neuro-cerebral system. I mean that this attribution rests, equally with the former, upon unifying a group of similar actions, which may take place in any of the various parts or organs of the central neuro-cerebral system, as a single entity.

The localisation of the highest sensori-motor centres of the various groups of special sensations in separate parts of the brain cortex stands on a very different footing from that of general functions, like those just enumerated. In their case a more or less separate localisation is justified, not only by the similarity of the sensations belonging to each

group, but by the similarity and peculiarity of the nerve-action, which we must suppose to be set up in special and separately localised peripheral organs, by similar and peculiar external stimuli, as for instance by ether vibrations impinging on the eye, air vibrations on the ear. Special physical forces, acting on specially constituted organs, would most readily tend to be propagated in special channels and to special centres. It remains to be discovered how far this consideration is applicable to the separate localisation of the emotions, as special modes of feeling, giving rise to special modes of appetition, and dependent on special modes of nerve-action. The true psychological problem is to explain the phenomena of consciousness, in their common-sense grouping and nomenclature, by referring them to the physical energies of the neuro-cerebral mechanism, as disclosed, on their part, simply and solely by anatomy and physiology. This explanation it is the special business of psychology to give.

To turn in the next place to the modes of consciousness subserved by the mass of intracranial nerve organs just described, so far as their functions are internuncial, elaborative, and governing. When I said above, that this whole group of organs, so considered, was not presentative of sensations, I did not mean to imply, that there was no class of feelings of which it was presentative. On the contrary, there is a large and widely diversified class of feelings which are native to it, and of which it is repeatedly presentative for the first time, as well as redintegrative or representative afterwards; just as an organ of sense is repeatedly pre-

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sentative of its appropriate sensations. I mean the whole class of feelings known as affections, emotions, passions, or sentiments, in whatever terms its various subdivisions may be spoken of, as for instance the feelings of need, appetite, desire, interest, grief, joy, love, anger, hate, and so on. These arise first in redintegration or representation, and this is the circumstance which distinguishes them from sensations, and gives them their specifically affective character. It is not a difference in point of vividness. Anger, for instance, may be as keen and poignant as many a so-called physical sensation, and the representation of anger is quite different in keenness from the presentation of it, or as we say the feeling of anger itself. The passion of anger is an intense and for the moment uncontrolled degree of the emotion of anger, both being presentatively felt. The representation of the emotion or passion, as they have been presentatively felt, may perhaps be best called the sentiment of anger. The true differentia is, that anger, like all emotions, arises only as the accompaniment of some representation or idea, which we commonly call the idea of its object, and which is drawn ultimately from sense-perceptions. It follows, that the whole class of affective or emotional feelings, with all its rich furniture of pleasures and pains of emotion, as distinguished from pleasures and pains of sensation, has for its proximate physical substrate the group of organs and functions which we are now considering.[6]

[6] For a somewhat detailed analysis and classification of the emotions, with their representational framework or imagery, I may refer to my *Theory of Practice*, 1870, Book I., Chap. II., Parts 2 to 5, (Vol. I., pp. 95 to 334). I must however remark, that the terms *reflection* and *reflective* are used very differently in that work, and in a far narrower sense than that which I have given them in the present.

The same is true of the whole range of states and processes of consciousness, of which representation is the basis. For purposes of description we may group the experience which they compose under the five heads, named from what is predominant in them, of experience intellectual ; active ; simply affective and emotional ; æsthetic and poetic ; ethical and religious. It is with representation and redintegration, with ideas and association of ideas, as distinguished from sensations or sense-perceptions, that experience of each of these five kinds begins ; and within their limits, though possibly not without the intermediation of transeunt action, it is developed.[7]

There is no state or process of consciousness, belonging to any one of these heads, which is exclusively that which its class name expresses. Every such state or process belongs inevitably to one or more of the other classes also. Every intellectual idea, for instance, has some affective, or æsthetic, or moral character, besides being an intellectual idea. The main line of distinction, but one always to be understood as a distinction not as a separation, which is common to all these phenomena, is that between spontaneous and voluntary states or processes of consciousness. The distinc-

[7] See, as bearing on this point, Professor William James's now classical article *The Feeling of Effort*, and Professor H. Münsterberg's well-known work *Die Willenshandlung;* to which I may now add, what has appeared since the last few paragraphs of my text were penned, Professor James's striking theory relative to the emotions, in his *Principles of Psychology* (1890) ; Chapter XXV. (Vol. II., pp. 442 to 485).—But this notwithstanding, it still continues impossible, in my opinion, that any amount of representation or redintegration of sensations, whether they be systemic, or special, or received back from our own motor actions, as in Professor James's theory, can ever account for the specific nature of the emotional experiences which accompany and pervade those representations. Emotions, appetites, and passions, seem to me to be a class of feelings *sui generis*, originating *de novo* in the organs which subserve representation, and not mere transformations and elaborations of the sensations or sense-perceptions represented.

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tion itself belongs to the phenomena of active life. We know the states and processes of volition as purposive attention, choice, resolution, determination of end or purpose, aspiration, and so on. But it is obvious that these pre-suppose and build upon spontaneous states and processes, out of which they spring, and of which they are modifications. Thus there is no conception, judgment, comparison, or reasoning, in intellectual life, which as such, that is, in its original coming to pass, does not involve volition, in the shape of attention to a perceptual content, for the purpose of knowing it more completely than as offered spontaneously in perceptual form.

The ascertainment of the precise modes of correspondence between the vast and varied process-content of consciousness, which falls under these five general heads, and the various regions, channels, and modes, of nerve and nerve action, on which their actuation depends, is perhaps the chief part of the task which now lies in prospect before experimental psychology. For instance, the question will press for a solution,—What part is played, in the phenomena of volition as a whole, by transeunt nerve action directed upon muscles and other tissues, and their consequent re-action upon central nerve organs through sensory channels; as for example, in the case of the influence exerted by the effort to speak upon thought, or of that muscular fixation which we exert when we attend to visually represented images? So also will the question, Whether efferent nerve action, simply as and while efferent, is attended with consciousness, unless indeed it may be held to have been already settled

in the negative, conformably to the view advocated by Professor W. James, in his paper already cited on *The Feeling of Effort.*

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One thing, however, is certainly to be anticipated, the facts disclosed by experimental psychology will gradually but surely force psychologists generally to adopt, as some have adopted already, the distinction between nerve and consciousness as the fundamental distinction of their science, instead of using terms like *mind* and *mental*, as too many still do, ambiguously, meaning by them at one time consciousness, at another the Subject of consciousness and its powers; whereby they stave off for the time an open rupture with a popular but unphilosophical ontology. For psychology there is no mind but nerve; nerve is the proximate real condition on which consciousness depends; the existence of mind as an immaterial Subject of consciousness has no warrant in experience. Their superstitious reverence for a common-sense and therefore non-philosophical ontology is what chiefly hinders psychologists from bringing themselves into line with experiential Metaphysic.

In what remains of the present work, we shall be busied almost exclusively with the states and processes of consciousness which belong to the five main heads just enumerated. These it is which are directly subserved by the great mass of the intracranial organs, in those internuncial, elaborative, and governing functions, which we have seen distinguished above, abstracting on the one hand from sensations or sense-perceptions proper, which are the basis of our knowledge of an external world, as already shown in Book I., and

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abstracting on the other from those overt or transeunt muscular actions which are the final actual dealings of the organism with the external world, and with itself as part of it. The field so marked out contains the whole of what is commonly called intellectual moral, and spiritual, life and experience. Some knowledge of the nerve mechanism on which these phenomena depend must therefore be pre-supposed; that is to say, so far as may be necessary for understanding the general mode of their connection with other parts of the total panorama of experience. I do not, however, propose to attempt a complete enumeration and classification of the total wealth of consciousness belonging to this vast group. I shall regard its phenomena as evidencing the nature of the immanent action of the conscious being, whether this action is spontaneous or voluntary. It is in the nature of this action that the primary interest of philosophy is centred. On the one hand, man's idea of moral obligation, which is the basis of Ethic, and on the other, the beliefs with which he peoples the unknown world, beyond the region of positive knowledge, which are the embodiment of Religion, have here their origin.

As Matter in its lowest forms seems to spring out of unknown real conditions, at some epoch or epochs which we imagine as the origination of its existence, and the starting point of its history and development, so, by the consciousness which accompanies its most complex and elaborate structures, it seems to point forwards to a knowledge of that same unknown region, to which its real conditions belong, though only by way of

anticipatory belief which cannot be verified by sensations depending on material organs. Imagination takes forms which cannot be verified, that is, the objects of which cannot be perceived, by means of sensations similar in kind to those out of which they sprang. This must be fully and frankly admitted. But, at the same time, this does not rob those forms of value, taken simply as imaginations; neither does it preclude enquiry into the inseparability of their connection, in some cases, with the constant modes of action inherent in conscious beings. The imaginations, for which such an inseparable connection should be established, would then likewise rank as constant and inherent, and share whatever validity might attach to their being founded in the essential structure and functioning, as distinguished from the acquired knowledge, of the conscious beings who possess and entertain them.

End of Book II.